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OSS SABOTAGE & DEMOLITION MANUAL

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CHAPTER I. EXPLOSIVES

SECTION 1. GENERAL INFORMATION ON EXPLOSIVES

A. Explosives as Agents for Sabotage and Guerrilla Warfare

Explosives are a favorite tool for saboteurs and guerrillas because they are effective, dramatic in action, and the best and most obvious tool for the destruction of many machines, structures, and other targets. Where subtlety is of minor consideration and destruction is the principal aim, explosives may be superior to any other tool in demolishing heavy, sturdy, noncombustible structures or machinery.

The saboteur should be very subtle in obtaining, storing, placing, and firing explosives, for if explosives are found away from their normal places the enemy will become aware of sabotage intent. Explosives may be molded and colored to resemble coal, wood, or any number of objects (which then may be smuggled into a target facility). When explosives are used to destroy or damage a target, the saboteur and guerrilla must anticipate a thorough investigation throughout the target facility and, if necessary, be prepared with a good alibi.

B. How Explosives Work

There is no magic about explosives. They are usually solids or liquids which, when subjected to shock or heat, will react instantaneously, forming a large volume of gas which is many times greater than the volume of the original solid or liquid. The chemical reaction develops heat, which further expands the liberated gases. Remember that the gases are produced very suddenly, perhaps in a thousandth of a second, and that they must escape. This they do by pushing in all directions. This push is so sudden that enormous pressures develop--as much as half a million pounds per square inch. Contrast this with the pressure in a steam boiler, which is normally only a few hundred pounds per square inch.

C. Types of Explosives

The speed with which the explosive is converted into gaseous products varies widely with different substances. Two types of explosives are recognized: high explosives and low explosives.

<u>High explosives</u> have such a rapid rate of reaction, traveling throughout the entire exploding mass, that the rush of newly formed gas is almost instantaneous. This is called detonation. The result is a

sudden, shattering blow--called the blast wave--which is extremely effective in demolitions. The blast wave travels through the explosive mass at incredible speeds; for example, some explosives detonate at the rate of 26,000 feet per second--almost 5 miles per second, or 18,000 miles per hour. Common high explosives are TNT, compositions C-3 and C-4, tetrytol, nitrostarch, PETN, dynamite, and ammonium nitrate.

Low explosives involve an entirely different reaction called deflagration. A deflagrating explosive burns progressively over a relatively sustained period of time as compared with a detonating explosive, which decomposes practically instantaneously. Common low explosives are black powder and smokeless powders. When these are initiated in the open, they burn at an extremely rapid rate. They become explosive only when the gases generated by the combustion are confined. Their principal use is as propellants. They have little use in sabotage and demolition, since their slow rate of reaction is worthless where a shattering or cutting effect is necessary.

D. Technical Terms Relating to Explosive Characteristics

There are literally dozens of distinctly different manufactured explosives. Some of the properties and characteristics of these explosives will now be defined:

Brisance. The intensity with which a high explosive decomposes is usually indicated by reference to its velocity of detonation expressed in feet per second, but a more general term is brisance, or shattering effect. A high explosive like TNT, with a velocity of detonation somewhat over 21,000 feet per second, would be called a very brisant explosive. Generally, the higher the velocity of detonation the greater the brisance of the explosive.

Chemical Stability. This is the ability of an explosive to retain its explosive characteristics over long periods of time at extremes of temperature. It is, of course, of importance in the problem of storing or caching of explosives for use at some later date.

Density. This is the weight of explosive per unit of volume. The velocity of detonation of a given explosive increases if it is compressed until it has a higher density. For instance, TNT in granular form detonates at a velocity of approximately 16,400 feet per second; the same material cast into a dense block detonates at about 21,000 feet per second, and if compressed to maximum density has a detonation velocity of approximately 23,000 feet per second. However, since maximum compression increases sensitivity, the degree of density must be carefully controlled.

Force of Explosive. The total energy of an explosive is the sum of its shattering (percussive) and propellant forces. For comparative relationship between different explosives, the detonation force of TNT is taken as the standard and is expressed numerically as 1.0. For example, the relative effectiveness factor of composition C-4 is 1.30, i.e., C-4 has an explosive force 30 percent greater than that of TNT.

Hygroscopicity. This term refers to an explosive's tendency to absorb and retain moisture. A good explosive should not gather or retain moisture. Often the terms soluble or insoluble are used to indicate the reaction of the explosive to moisture.

Relative Effectiveness. See Force of Explosive, above.

Sensitivity. A good explosive should not detonate from the mechanical shocks to which it may be subjected during shipment and routine handling. Also, it should not detonate when a rifle bullet is fired into it. On the other hand, it must be sensitive enough to be detonated at high order by standard initiators (blasting caps). Controlled sensitivity is therefore a desirable characteristic of an explosive.

Velocity of Detonation. See Brisance, above.

SECTION 2. MILITARY AND COMMERCIAL EXPLOSIVES

A. Characteristics of Principal Explosives

Before taking up the various principal explosives in detail, it might be instructive to examine Chart 1, which compares some of them.

Most of these explosives may be used interchangeably, but some are more suitable than others for certain applications. In using the table to determine which type of explosive to use, both velocity of detonation and relative effectiveness are considered. Of two explosives having about the same velocity of detonation, the one having the higher relative effectiveness factor should be chosen for cutting steel or breaching concrete. For example, nitrostarch and 40-percent straight dynamite detonate at the same velocity (15,000 fps). Nitrostarch is more suitable for cutting since its relative effectiveness factor is higher. Notice that velocity of detonation and relative effectiveness apply only to the high explosives. With low explosives the chemical composition, size of grain or unit, atmospheric pressure, etc. affect the rate of combustion so much that definite results cannot even be predicted in a general way.

Chart 1. Characteristics of Principal Explosives

TYPE	NAME	USE	RELATIVE EFFECTIVENESS	VELOCITY OF DETONATION (in feet per second)	CAP REQUIRED TO FIRE EXPLOSIVE
I. HIGH EXPLOSIVES	MILITARY				
	TNT	Steel cutting and general demolition use	1.00	21,000	Special blasting cap
	COMPOSITION C-3	"	1.26	25,000	"
	COMPOSITION C-4	"	1.30	26,370	"
	TETRYTOL	"	1.20	23,000	"
	NITROSTARCH	"	0.86	15,000	"
	AMMONIUM NITRATE	Cratering	0.42	11,000	"
	COMMERCIAL				
	STRAIGHT DYNAMITE	Clearing land, cratering, rear-area military use			
	40%		.65	15,000	No. 6
	50%		.79	18,000	"
	60%		.83	19,000	"
	AMMONIA DYNAMITE	"			
	40%		.41	9,000	No. 6
	50%		.46	11,000	"
	60%		.53	12,000	"
	GELATIN DYNAMITE	"			
	40%		.42	8,000	No. 6
	50%		.47	9,000	"
	60%		.76	16,000	"
	BLASTING GELATIN	Steel cutting and general demolition in rear areas	0.92	20,000	No. 6
II. LOW EXPLOSIVES					
	BLACK POWDER	Cratering, propellants time fuse			Flame
	SMOKELESS POWDERS	"			"

B. Military High Explosives: Demolition Explosives

Military high explosives are preferred for sabotage operations. They are very powerful, possess the characteristics necessary to withstand rough handling and treatment, and stand up well in poor storage conditions. Some of the more common military explosives are described below.

1. TNT

TNT (Trinitrotoluene) (see Fig. 1) is produced from toluene, sulfuric acid, and nitric acid. It is a powerful high explosive with a velocity of detonation of about 21,000 feet per second. It is well suited for steel cutting, concrete breaching, and general demolition.

TNT is the standard upon which the relative effectiveness of other high explosives is based. Numerically it is rated as 1.0.

TNT is relatively insensitive to shock. It will not detonate on the strike of a single rifle bullet, but may do so under sustained machinegun or rifle fire.

TNT may vary in color from a pale yellow to an orange. Its color is influenced by time and by the purity of the explosive.

TNT is crystalline and is issued in pressed form. It can be steam melted. It burns at 266° F. Small quantities (up to 1 pound) of it may be burned in open areas without fear of detonation.

TNT is toxic; TNT dust should not be inhaled in quantity or allowed to contact the skin excessively. The gases produced by an explosion of TNT are poisonous.

TNT is stable--quantities of it have maintained their characteristics for periods of 20 years.

TNT is insoluble and is suitable for underwater demolitions.

TNT is issued in 1-pound and ½-pound containers (see Fig. 1) with 50 pounds to a wooden box.

The 1-pound package consists of two ½-pound blocks in a cardboard container with lacquered metal ends. There is a threaded cap well at one end of the container.

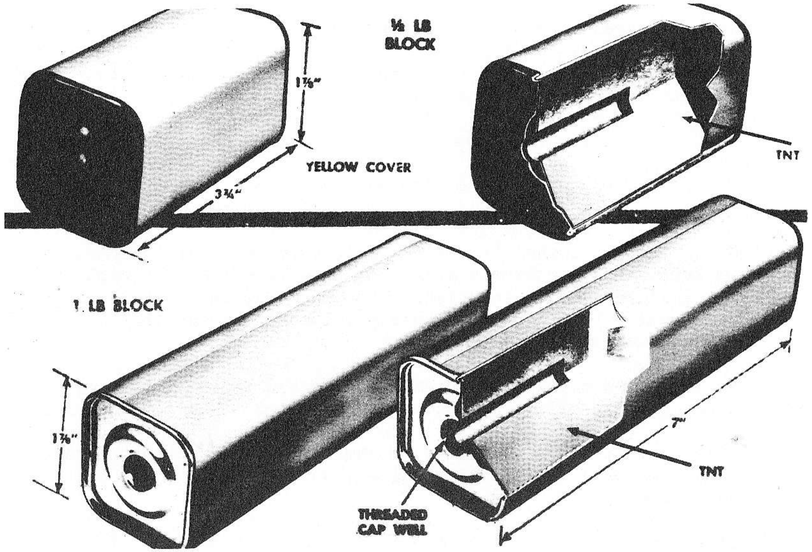


Figure 1

The ½-pound package is issued in a yellow cardboard container with lacquered metal ends. There is an unthreaded cap well at one end of the container.

TNT may be consistently detonated with the Special blasting cap or by a few turns of primacord.

2. Composition C Series (Compositions C-3 and C-4)

The Composition C explosives are often called "plastic explosives" because of their puttylike consistency, which permits them to be pressed into intimate contact with a target. The important chemical ingredient in the compositions is RDX (trimethylene trinitramine or cyclo trimethylene trinitramine), which got its name from its British discoverers' "Research Division formula X." RDX has a greater shattering power than TNT, but is too sensitive to be used by itself and hence is mixed with certain desensitizers.

a. Composition C-3

Composition C-3 (see Fig. 2) is about 75 percent RDX and 25 percent a mixture of TNT, DNT (dinitrotoluene) oil, MNT

(mononitrotoluene), and other ingredients. It is more powerful than TNT and has a higher velocity of detonation (25,000 fps). Its sensitivity and stability are comparable to that of TNT.

C-3 is a yellow-orange, puttylike substance which has a distinctive odor. It exudes an oil, particularly at high temperatures, which apparently does not impair its explosive qualities. Handling causes a yellowish discoloration of the hands which is difficult to remove.

C-3 maintains its plastic consistency between -20° F and 125° F. At temperatures below -20° F the explosive becomes solid and brittle; at temperatures above 125° F it becomes mushy and exudes considerable oil.

C-3 may be burned in small quantities without exploding. If burned in confinement or in large quantities, it explodes.

C-3 is not recommended for use in closed spaces because its explosion produces poisonous gases.

C-3 is insoluble in water and may therefore be used under water.

C-3 is consistently exploded by the Special blasting cap or by a few turns of primacord.

(1) Military Issue of Composition C-3

M3 Demolition Block (See Fig. 2). This is a 2¼-pound block which is wrapped in glazed paper and inclosed in a labeled, olive-drab cardboard carton. Eight blocks are packed in an olive-drab cloth bag with carrying strap. Two bags, 16 blocks, are packed in a wooden box.

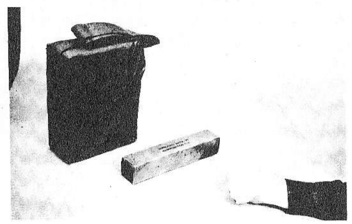


Figure 2

b. Composition C-4

Composition C-4 (see Fig. 3) contains somewhat more RDX than its predecessor, C-3. The RDX is the only compound common to both explosives. C-4 contains a small percentage of SAE 10 motor oil, as well as other ingredients. C-4 is more powerful than C-3 and has a higher velocity of detonation (26,370 fps). Its sensitivity, stability, and solubility characteristics are generally the same as those of C-3.

C-4 is a white, plastic substance having the appearance and consistency of nougat candy. It is odorless and does not exude oil.

C-4 maintains its plastic consistency between -70° F and 170° F.

C-4 is nontoxic.

C-4 is issued in 2½-pound blocks packed in cardboard containers. (See Fig. 3.)

C-4 is consistently exploded by the Special blasting cap or by a few turns of primacord.

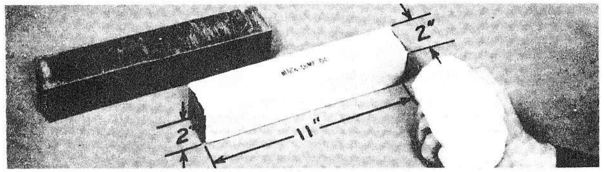


Figure 3

3. Tetrytol

The major component of tetrytol (see Figs. 4 and 5) is tetryl (tri-nitro phenyl methyl nitramine), an extremely powerful and sensitive explosive. To desensitize tetryl to the point where it can be used for military-demolition purposes, TNT is combined with it. It is more powerful and has a higher velocity of detonation (23,000 fps) than TNT. It is, therefore, suited for any demolition purpose for which TNT is used.

Tetrytol is a bright yellow, crystalline compound which is cast in 2½-pound blocks.

Tetrytol is relatively insensitive, so that a ½-ounce tetryl booster pellet must be cast into either end of the block in order that it may consistently be exploded by the Special blasting cap or by a single strand of detonating cord.

Tetrytol is similar to TNT in all other respects, i.e., stability, etc.

Tetrytol may be burned in small quantities (up to a half pound) without danger of a detonation, so long as the explosive is not confined.

a. Military Issue of Tetrytol

(1) M1 Chain Demolition Block (See Fig. 4). Eight 2½-pound blocks of tetrytol, 8 inches apart, are cast onto a single line of detonating cord which passes lengthwise through the blocks. Two feet of cord are left free at each end of the chain of blocks. One chain is packed in a standard olive-drab carrying bag. Two bags, 16 blocks, are packed in a wooden case.

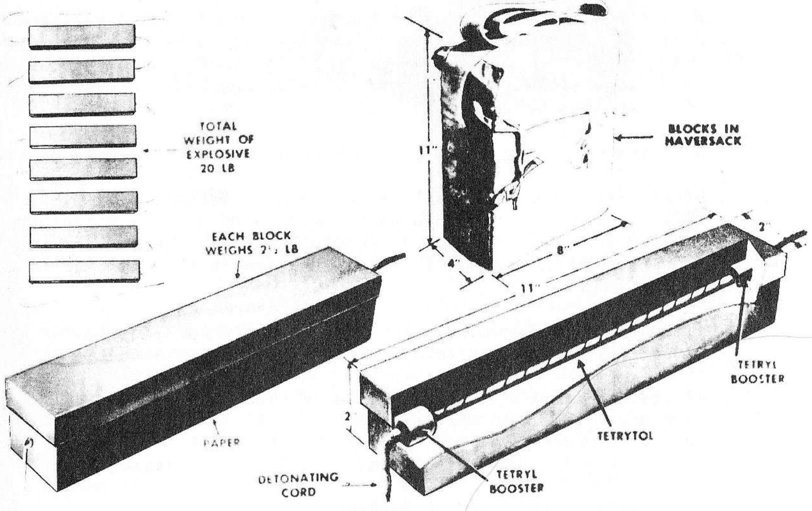


Figure 4

(2) M2 Demolition Block. The M2 demolition block (see Fig. 5) is similar to the M1 block except that each block has a threaded cap well and a booster pellet at either end. The standard carrying bags contain eight blocks and there are two bags, 16 blocks altogether, per case.

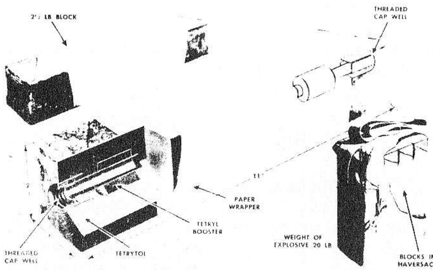


Figure 5. M1 Chain Demolition Block

4. Nitrostarch

A cassava, tapioca, or other starch nitrate is mixed with barium nitrate and sodium nitrate to form the explosive known as nitrostarch (see Fig. 6). It was originally manufactured to relieve a shortage of TNT. It is less powerful and has a slower velocity of detonation (15,000 fps) than TNT.

Nitrostarch is a silvery gray powder which is pressed into blocks.

Nitrostarch is more sensitive to flame, friction, and impact than TNT. It will not detonate on the strike of a rifle bullet; nevertheless it should be handled carefully. Small quantities (up to a quarter pound) may be burned in the open without danger of detonation.

Nitrostarch is somewhat hygroscopic and should be detonated promptly if used underwater.

Nitrostarch should not be used in confined spaces, as the explosive gases produced are toxic.

Nitrostarch is issued in 1-pound and ½-pound packages.

a. Military Issue of Nitrostarch

The 1-pound package (see Fig. 6) can be broken down into ¼-pound blocks. A cap well extends through the length of the

¼-pound blocks, and its position is indicated by circles on the paraffin-treated wrapper of the 1-pound package. Fifty 1-pound packages are packed in a box.

The ½-pound block is issued in the same type of cardboard container as the ½-pound block of TNT. One hundred blocks are packed in a box.

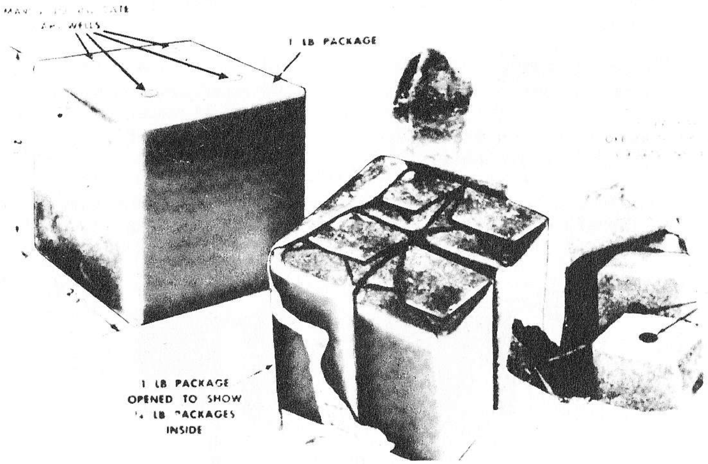


Figure 6

5. Ammonium Nitrate

Although ammonium nitrate (see Fig. 7) is classified as a high explosive because it may be detonated, it is generally unsuitable for any purpose other than cratering. This is so because of its extremely low velocity of detonation (3,600 fps); it is less sensitive to shock, friction, and flame than any of the explosives so far discussed. Ammonium nitrate is used primarily as an additive in other explosive compounds. When it is used alone for earthmoving purposes it must be initiated by a powerful booster or primer, since it is too insensitive to the shock resulting from a Special blasting cap or a few turns of primacord.

Ammonium nitrate is a white, crystalline substance which is extremely hygroscopic; for this reason it will usually be found packed in a sealed metal container similar to the Army's 40-pound cratering charge (see Fig. 7).

Notice that the booster explosive comprises about 20 percent of the entire volume.

The velocity of detonation of this particular charge is 11,000 feet per second. (The booster is responsible for the increased speed.)

The gases produced by the explosion of ammonium nitrate are poisonous.

Ammonium nitrate should always be double primed, i.e., a Special blasting cap or strand of primacord should be inserted in the well or tunnel of the charge and a primed block of TNT or other explosive should be placed beneath or on top of the container, within the borehole.

(Note: Never use a container which has been punctured. Ammonium nitrate will absorb enough atmospheric moisture to render it ineffective after a few hours of exposure.)

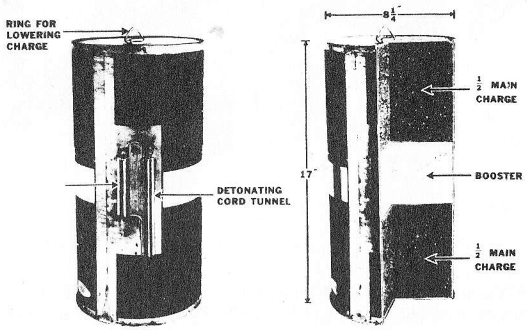


Figure 7. Ammonium Nitrate Cratering Charge

C. Commercial Explosives

1. High Explosives

The explosives discussed in this section are sold commercially for roadbuilding, quarrying, mining, agricultural, and other civilian blasting operations. They are therefore easily obtainable if military high explosives are not. Dynamites are the most important class of commercial explosives, and since dynamites all

contain nitroglycerin, a discussion of this latter substance is in order before dynamites are discussed.

a. Nitroglycerin

Formula $C_3H_5(NO_3)_3$. Notice that nitroglycerin contains the nitrate (NO3) group, not the nitro (NO2) group. Its proper name is therefore glyceryl trinitrate, not nitroglycerin, but custom has long permitted this misnomer.

Nitroglycerin is manufactured by treating glycerin with a nitrating mixture of nitric and sulfuric acid. The glycerin is a byproduct in the manufacture of soaps.

Nitroglycerin is a thick, clear-to-yellow-brownish liquid which is an extremely powerful (velocity of detonation 24,400 feet per second) and shock-sensitive high explosive. Small quantities of nitroglycerin may be burned, but there is always an attendant danger of detonation.

Nitroglycerin freezes at 56° F, in which state it is less sensitive to shock than in liquid form.

Skin contact with nitroglycerin can cause a toxic effect which is characterized by severe headaches.

Nitroglycerin is insoluble and is slightly volatile.

b. Dynamites

There are several types of dynamites in regular use, and each is different from the others in one or more characteristics or properties. Some of the principal properties are: force, density, velocity, water resistance, fumes as products of detonation, etc.

Prior to further discussion of dynamite characteristics, the three principal types of dynamite (see Chart 1) should be mentioned:

(1) Straight Dynamite

This type of dynamite contains nitroglycerin as the only material which, by itself, is explosive. Nitroglycerin and a freezing-point depressant are absorbed by "dope," a mixture of carbonaceous material (nut meal, woodpulp, etc.). The dope may contain an oxidizer such as sodium

nitrate and an antacid. Dope is nonexplosive but is energy producing. It replaces the inert kieselguhr (diatomacious earth) which formerly served as the absorbent in dynamites.

(2) Ammonia Dynamite

This type of dynamite contains, in addition to the nitroglycerin, varying amounts of ammonium nitrate as an ingredient of the dope.

(3) Gelatin Dynamite

The explosive base of gelatin dynamite (see Fig. 8) is a jelly made by dissolving nitrocotton in nitroglycerin. To this are added other energy-producing ingredients.

Each of the above types is further subdivided into a series of grades.

Figure 8

Strength or force, of course, refers to the energy content of the explosive. Straight dynamites are rated in strength according to the percentage by weight of nitroglycerin which they contain; i.e., 40-percent straight dynamite actually contains 40-percent of nitroglycerin by weight. Forty-percent ammonia and gelatin dynamites are compounded to produce the same energy as a 40-percent straight dynamite, even though the former contain much less than 40-percent of nitroglycerin. Straight dynamites are, therefore, the strength references for all dynamites. An erroneous concept regarding dynamite is that the explosive energy developed by different strengths is in direct proportion to nitroglycerin content, i.e., that 40-percent dynamite is twice as strong as 20-percent. Such a simple ratio does not exist, because a decrease in nitroglycerin means an addition of other energy-producing ingredients.

Dynamites range in velocity of detonation from about 4,000 to about 23,000 feet per second. Two dynamites of

the same strength, i.e., a 40-percent straight dynamite and a 40-percent ammonia dynamite, do not necessarily produce the same blasting action in the field. This is due primarily to the difference in the velocities.

Generally speaking, dynamites are too unstable for military demolitions. With some types their nitroglycerin tends to separate from the other ingredients. This results in leaky cartridges and hazardous concentrations of nitroglycerin. To avoid this, it is recommended that dynamite cases be placed so that the cartridges lie horizontally and that the cases be turned over every 30 days.

Although most dynamites will resist freezing at temperatures considerably below the freezing point of nitroglycerin, the possibility remains that after long exposure to subzero temperatures dynamite may become frozen. It may be so insensitive in this state that detonation may be incomplete or impossible. (One test for frozen dynamite is that if the dynamite resists the passage of a small nail through its mass it is frozen.) It may be thawed in air at a temperature of 90° F. Partially thawed dynamite is extremely sensitive and should never be handled.

A second method of thawing dynamite requires equipment similar to that shown in Fig. 9. Water which is as hot as the human hand can stand is poured into the water compartment of the dynamite-thawing kettle. The frozen dynamite is stacked so that air may circulate around each cartridge in the explosive compartment. No more than a few pounds should be thawed at a time. The explosive should never be placed in its compartment until the water has been poured. The water compartment should never be placed over a fire or other source of heat.

All dynamites are extremely sensitive. They will detonate on the strike of a rifle bullet. A No. 6 blasting cap will consistently detonate them.

Gelatin dynamites are not appreciably affected by moisture and may be used under water. They are the most powerful of the dynamites.

Straight dynamite may be used under water so long as the waxed paper containers remain intact. It is recommended

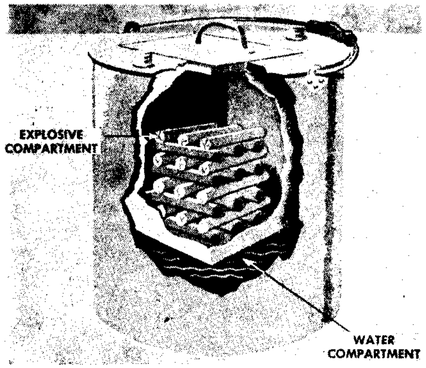


Figure 9

Dynamite-Thawing Kettle

that submersion be limited to 24 hours. Since ammonium nitrate is an ingredient of ammonia dynamites, and since it is hygroscopic, it is recommended that ammonia dynamites be used for relatively dry work.

The dynamites available today indicate the progress made by the explosives industry in developing types and grades of explosives suitable for specific purposes. Generally, the straight dynamites deliver quick, shattering action; because of the toxicity of their fumes, they are unsuitable for underground work. Ammonia dynamites, being slower than straight dynamite, produce heaving rather than shattering action; their fumes are such that they may be used underground. The gelatin dynamites are adapted to all varieties of wet work and the high strengths are suitable for hard-rock blasting; however the high strengths produce such quantities of toxic fumes that their use in confined areas is not recommended.

Although dynamites are furnished in a wide variety of packages, the most common unit is the $\frac{1}{2}$-pound cartridge. This is 8 inches long by $1\frac{1}{4}$ inches in diameter and is wrapped in paraffin-treated paper. Fifty pounds of dynamite is the maximum weight per case.

c. Blasting Gelatin

Blasting gelatin is considered the most powerful industrial explosive. Its characteristics are similar to those of gelatin

dynamite, with the exception that blasting gelatin is more water-resistant. It is a translucent material of an elastic, jellylike texture and is manufactured in a number of different colors. It is packed in various sizes as paper-wrapped slabs or cartridges.

d. Other High Explosives

The employment of military explosives for commercial purposes is permitted by certain governments. This is particularly true with explosives similar to ammonium nitrate, which is extremely insensitive and highly suitable for quarrying, surface blasting, etc.

2. Low Explosives

Low explosives are burning rather than detonating compounds. Because of this progressive burning or deflagrating, low explosives are unsuitable for general demolitions. Their demolition utility is limited to earth blasting, where they can be carefully loaded and closely confined (tamped). In such applications they have a shearing and heaving action which tends to blast material into large, firm fragments.

Low explosives are used primarily as propellants. These may be removed from all types of fixed ammunition and employed to advantage as explosive fillers for improvised pipe grenades and booby traps.

The principal low explosives are black powders and smokeless powders.

a. Black Powder

Black powder (see Fig. 10) is a mixture of approximately 10 percent sulfur, 15 percent charcoal, and 75 percent sodium or potassium nitrate. It is manufactured in granular and pellet form. Black blasting powder, the granulated form, is a loose, free-flowing, definitely grained material. Its burning speed is controlled by grain size--the finer the granulation the faster the burning. It is used in quarrying fine-dimension stone and in shooting coal; also, it is used in the manufacture of fireworks and time fuses.

Pellet powder is an improved form of black powder. The powder is pressed into small pellets to facilitate handling. Each pellet has a center hole for priming purposes. Pellet powder is less dangerous to handle, is more efficient, and is more economical to use than is granular powder.

Since black powder is soluble and hygroscopic, the waxed-paper-pellet form provides a measure of protection from dampness. Pellet powder is designed primarily for borehole shooting, such as in underground coal and clay mines. Black powder has little percussive ability and is therefore preferred to dynamite for some uses.

Black powder is extremely sensitive to flame or spark. It should not be stored with high explosives.

In its granular form, black powder is issued in 25-pound drums, and in its pellet form in 50-pound wooden cases.

Black powder is initiated with a time fuse or an electric squib.

b. Smokeless Powder

Smokeless powders are used as propellants. The term "smokeless powder" is a paradoxical misnomer, for the substance is not entirely smokeless and it is not a powder. The base of smokeless powders is a colloid formed by action of a solvent upon a nitrated cellulose, with or without the addition of nitroglycerin. The following compounds are referred to as smokeless powders: pyropowder, FNH and NH powders, double-base powders, and EC powder. Smokeless powder is manufactured in the form of small flakes, strips, pellets, sheets, or perforated cylindrical grains. The grain size may vary from a small (0.032 inch by 0.085 inch) grain used in rifle ammunition to a large (0.947 inch by 2.170 inch) grain used in 16-inch guns.

Although smokeless powders are generally insoluble they are somewhat hygroscopic, and since their performance is influenced by moisture content they should be carefully packed. Smokeless powders are not so sensitive to flame as black powder. It may, therefore, be necessary to include a first-fire mixture within any improvised grenade or other explosive device.

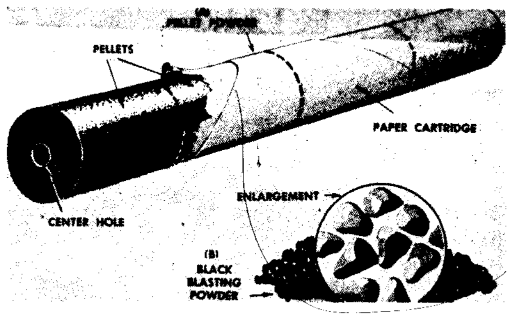


Figure 10

Black Powder

SECTION 3. INITIATING SUPPLIES AND DEVICES

Initiating supplies and devices are employed in making up priming charges of explosives. They are generally consumed in the blast.

A. Safety Fuse (Time Fuse)

Safety fuse (see Fig. 11) is a fuse which is used to transmit flame at a continuous and uniform rate to a spark-sensitive explosive charge, thus permitting the person who fired the fuse to reach a safe place before the charge explodes. It consists of a black-powder core which is overlaid with layers of jute, asphaltic compound, and a waxed textile outer covering. This preparation completely waterproofs the fuse; however, waterproofing techniques must be employed to protect the exposed powder core at cut ends.

Safety fuse is manufactured with a number of different burning rates. The most common type burns at the rate of 30 to 45 seconds per foot. The burning speed varies with atmospheric pressure, character of tamping, and conditions under which the fuse was stored.

Safety fuse is manufactured in a number of different colors. The more common of these are orange, white and black; however, recognition should never be based on the color of the cover since instantaneous fuses (see Section 9) often have the same appearance as safety fuses. A black core indicates only a burning fuse. Positive recognition is established when the burning rate of any black-cored fuse has been determined.

Safety fuse may be ignited by any source of flame.

Safety fuse is issued in 50-foot rolls. Two 50-foot rolls, one nested inside the other, are packed together.

Complete instructions on how to use safety fuse are included in Section 7.

B. Electric Squib

The electric squib is used to ignite low explosives electrically. It is a small--about one-quarter of an inch in diameter and 3/4 - 3 inches long--metal tube which is closed at one end and contains a few grains of a heat-sensitive incendiary mixture. Generally, the electrical part of the squib corresponds to the arrangement of the electric blasting cap which is described in Section 7. When sufficient current is applied to the leg wires, the ignition mixture flashes and ruptures the

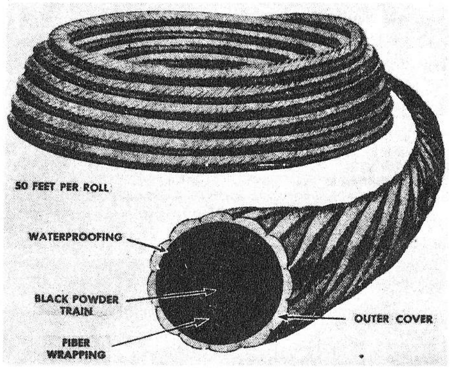


Figure 11

Safety Fuse

shell. Intense flame issues from the ruptured shell and ignites the low explosive. Squib-wire lengths vary from 4 feet to 12 feet. Fifty squibs are packed in a cardboard carton.

C. Percussion Cap

Percussion caps contain a small amount of mercury fulminate or other percussion-sensitive explosive mixed with an incendiary compound. They are primarily used as cartridge primers in all types of fixed ammunition. A percussion equal to that derived from a mechanical firing-pin mechanism is required to initiate them. They produce a jet of flame that is sufficient to ignite safety fuse or low explosive, or to explode a nonelectric blasting cap (see Booby Traps, Chapter II).

D. Blasting Cap

All demolition high explosives are initiated by electric or nonelectric blasting caps (detonators). These are small tubes or shells (see Fig. 12), usually about .22 inch to .25 inch in diameter by 1-3 inches long, which are closed at one end and loaded with one or more of the following compounds:

1. Lead Azide

Lead azide is a white-to-buff-colored crystalline explosive which is slightly less sensitive but more powerful than mercury fulminate. It is only slightly soluble and is nonhygroscopic, but moisture does impair its efficiency.

2. Mercury Fulminate

Mercury fulminate is a heavy, crystalline explosive which detonates completely and with great violence on ignition by means of a flame such as the spit from a fuse, percussion cap, etc. or by means of an electrically heated wire. It is white when pure, but ordinarily has a brownish-yellow or grayish tint. It is extremely sensitive to friction, shock, and heat. Mercury fulminate is only slightly soluble and is nonhygroscopic, but moisture does impair its efficiency. In addition to its use in detonators, mercury fulminate is mixed with flame-producing materials for use in percussion-type cartridge primers. In many countries, mercury fulminate has been replaced by less sensitive, more powerful compounds such as lead azide.

3. Tetryl

Tetryl (trinitrophenylmethylnitramine) is a fine, yellow crystalline which is more powerful than TNT. Pure tetryl is too shock-sensitive to be used as a demolition explosive; however, when small quantities are compressed into pellet form it is perfectly safe. Tetryl booster pellets are commonly used in bursting projectiles to assure the detonation of a less sensitive filler explosive. Tetryl is also compounded with TNT to form the demolition explosive tetrytol (see Section 2. B. 3.). Tetryl is practically nonhygroscopic and is insoluble. Tetryl will detonate if exposed to a temperature of 500° F.

4. PETN

PETN (pentaerythrite tetranitrate) is a white, crystalline explosive which is more powerful than TNT. It is too shock-sensitive to be used in a pure state for anything other than blasting caps. A desensitized PETN is used in detonating cord (see Section 3. E.).

5. Other Explosives

While the explosive compounds listed above are widely used as initiators, there are others, such as mannitol-hexanitrate, guncotton, mercury azide, etc., which may be used in domestic as well as foreign equipment.

6. General Information on Blasting Caps

Lead azide, mannitol-hexanitrate, or other priming compound may be the only explosive used in blasting caps; however, the modern

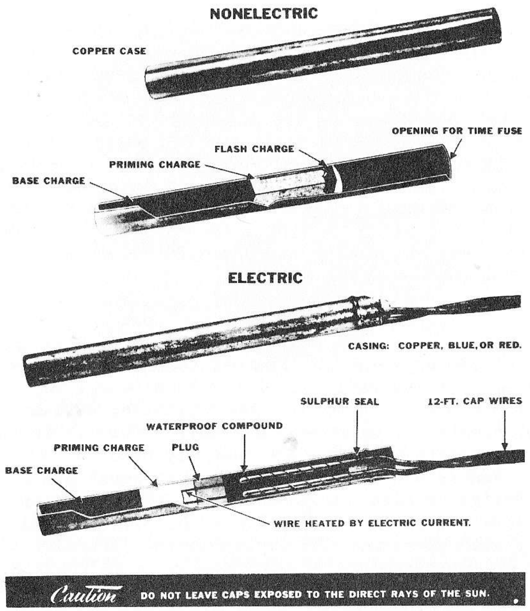


Figure 12

Blasting Caps

tendency is to use the above in combination with tetryl or PETN. Modern blasting caps are loaded as shown in Fig. 12. The base charge is comprised of a few grains of compressed tetryl or PETN. Of the two, PETN is the more suitable because of its greater power. The priming charge may or may not be mixed with potassium chlorate or other flash mixture. The nonelectric blasting cap shown in Fig. 12 has a separate flash charge, which is pressed over the priming charge. The outer shell of the blasting cap may be of copper, copper alloy, or aluminum. This is no indication of the explosive compounds inside the shell; however, lead azide is never used in copper or copper-alloy shells.

Blasting caps, electric and nonelectric, are manufactured in various strengths to suit the requirements of consumers. The strength of a blasting cap refers to the degree of energy production of which a cap is capable and not to the amount of explosive contained therein; for example, lead azide is more powerful than

mercury fulminate, and fewer grains of the azide are necessary to produce the energy derived from a larger amount of the fulminate. A No. 6 blasting cap delivers the necessary shock to detonate dynamites but not enough to detonate TNT consistently. A No. 8 blasting cap is more powerful than the No. 6 cap and is used in detonating boosters which are less sensitive than dynamites. The No. 8, however, will not consistently detonate TNT and other high explosives. The Special blasting cap was designed to meet the shock requirement of TNT and the other insensitive explosives in order that consistent detonation be assured. The caps required for positive detonation of various explosives are indicated in Chart 1.

Blasting caps are initiated by the spit of flame from a safety fuse or percussion cap or by electrically produced heat. They are extremely sensitive to shock, friction, and heat and must be handled and stored properly. They should not be stored with other explosives. Nonelectric caps cannot be initiated by a spark when moist or wet. Nonelectric caps may be used underwater when properly waterproofed (see Section 7. B. 1.d.).

Nonelectric caps are generally packed 100 to a small box or can.

Electric caps are equipped with two single-strand leg wires which are from 4 to 100 feet long. The special cap is issued with standard 12-foot leg wires. These lead through the open end of the cap and end within the priming charge, as is shown in Fig. 12. These ends are connected by a noncorrosive, high-resistance bridge wire which heats to incandescence with the application of sufficient electrical current. This firing element is held within the cap by a plug made of rubber or some other substance. An asphaltic waterproofing compound permits underwater use. The end of the cap is sealed with sulfur, nylon, or plastic. The enameled leg wires are covered with a waxed textile or plastic. A shunt or short-circuit tab connects the free ends of the leg wires and prevents external currents, static electricity, etc., from entering the cap. This is a safety device which must be removed before the cap can be placed in an electrical circuit.

Delay electric caps are similar to those already discussed, except that a burning-delay element is inserted between the electrical firing element and the explosive. Some delay caps are perforated to permit venting of gases formed by combustion of the delay element. Some delay caps may be of greater diameter and length than the regular caps. Delays vary from a few milliseconds to several seconds. Delay caps are ideal for certain types of commercial blasting; they are not ordinarily available to the military.

Electric blasting caps with wires 16 feet long or less are packed 50 to the cardboard carton. Those with longer wires are packed fewer to the carton.

Correct methods of using caps to prime explosive charges are covered in Section 7.

E. Detonating Cord (Primacord)

Detonating cord (see Fig. 13) is a high-explosive fuse which is used in making primers and for the simultaneous detonation of multiple charges. It is composed of an explosive core of PETN within a waterproof sheath of textile or plastic. PETN is an extremely powerful and shock-sensitive explosive. For this reason it cannot be used in a pure state as a military high explosive. When used in primacord it is desensitized with wax, which lowers its velocity of detonation from over 27,000 feet per second to about 20,000 feet per second. In this state, PETN will not detonate upon the strike of a rifle bullet. PETN is insoluble, but moisture desensitizes it to a point where it cannot be detonated by the Special blasting cap. PETN is a stable, white, crystalline compound.

Issue detonating cord contains 50 grains of PETN per linear foot.

Although textile-wrapped primacord usually has a yellow or yellow-black outer cover, this is not always the case. Recognition should not be based on the color of the cover. Primacord has a white powdery core.

Waterproofing is provided by an asphaltic compound and surface wax for textile-covered primacords. This provides underwater protection for 24 hours. Plastic-covered primacords provide waterproof protection for longer periods of time, and greater flexibility at low temperature. Waterproofing compounds must be applied to the cut ends of detonating cord when underwater use is intended. Otherwise, a 6-inch free end protects the remainder of a strand from moisture for 24 hours.

Textile-wrapped detonating cord becomes stiff and brittle at low temperature; care should be taken not to break the explosive train.

Short lengths, up to 1 foot, of detonating cord may be burned without danger of detonation.

Detonating cord is issued in 50-, 100-, 500-, and 1,000-foot spools.

Detonating cord is consistently detonated by a No. 6 or more powerful blasting cap.

Correct methods of using detonating cord for priming and linking explosive charges are covered in Section 7. B. 1. c.

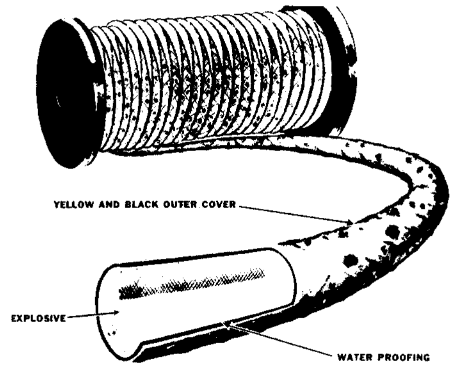


Figure 13

Detonating Cord

SECTION 4. DEMOLITION ACCESSORIES

Demolition accessories are those tools and devices which are necessary for the preparation, placement, and firing of explosive charges. While some of these accessories are sometimes consumed in the blast, many of them may be used repeatedly.

A. Nonelectric Equipment

1. Cap Crimper

The cap crimper (see Fig. 14) is a steel, plierlike tool used to affix blasting caps to time fuse. Its crimping edge is designed to crimp the shell of a nonelectric cap tightly enough around time fuse to prevent the cap's removal and at the same time not impair the powder train of the fuse. Its lower jaws are used as a fuse and detonating cord cutter. One leg of the handle, the punch, is used to fashion cap wells in dynamite and plastic explosives. The screwdriver end is handy for opening cases of explosives.

The M2 crimper has a narrow jaw that makes a water-resistant groove completely around the cap. Other-type crimpers may have wider crimping jaws which may not make a water-resistant seal.

Crimping tools should not be used as pliers--their crimping jaws may be damaged to a point where they no longer are suitable for crimping.

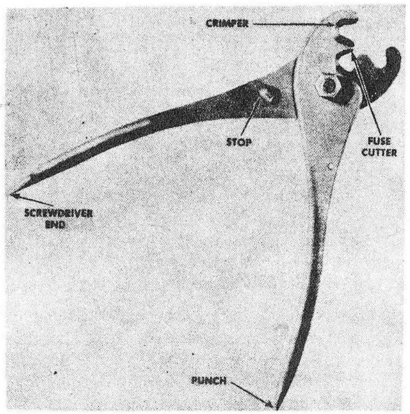


Figure 14

M2 Blasting Cap Crimper

2. Blasting Cap Boxes

Blasting cap boxes are wooden or plastic containers designed for carrying a few caps. They are nothing more than a multiple-recessed block which is provided with a cover. A small piece of felt or foam rubber provides a cap cushion at the base of each recess. They are made in sizes ranging from 6-cap to 50-cap capacity.

3. Fuse Lighters

There are a number of issue devices for the lighting of safety fuse. The more common of these are discussed in the order of their importance.

a. M2 Weatherproof Fuse Lighter

This device (see Fig. 15) will ignite fuse under all weather conditions and will even perform underwater, so long as submersion is limited to a few minutes. It consists of a barrel which holds the firing mechanism and a base which contains a percussion cap and a pronged fuse retainer. The barrel contains the striker-spring and striker, held locked in one end

by a release pin. The other end is threaded to fit over the base. The square end of a piece of safety fuse is pushed as far into the fuse retainer as possible. A plastic sealing compound is used to waterproof the joint of fuse and lighter. When the release pin is pulled, the striker explodes the percussion cap, which in turn ignites the fuse.

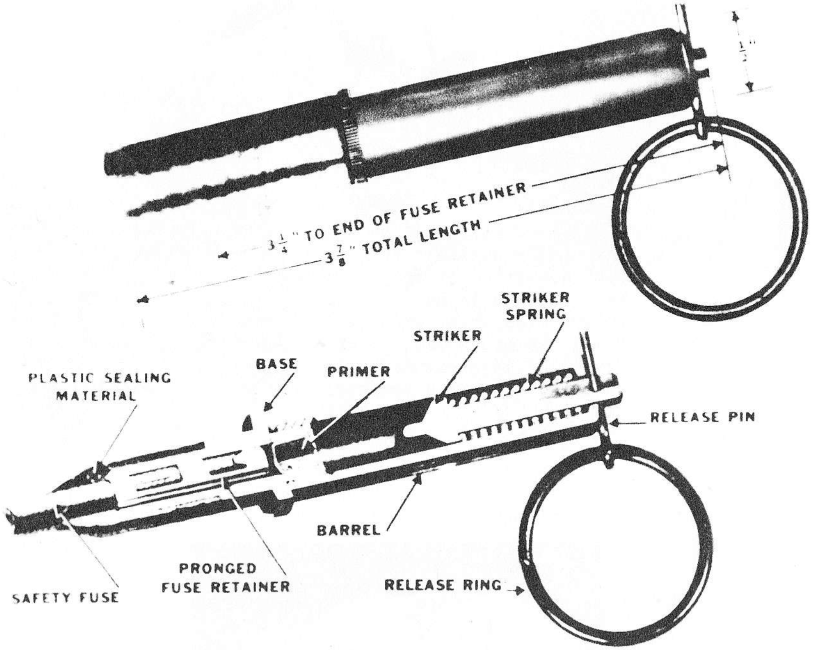


Figure 15

b. Fusee Matches

Fusee matches are strike-anywhere, windproof, and nonflaming igniters. They are used as shown in Fig. 16. The burning fusee is held so that an unburned part of its incendiary head is in contact with the powder train of a diagonally cut piece of safety fuse. The fuse will ignite as soon as the smolder reaches the powder train. The fusee will not function when wet. Fusees are packed in standard safety match boxes.

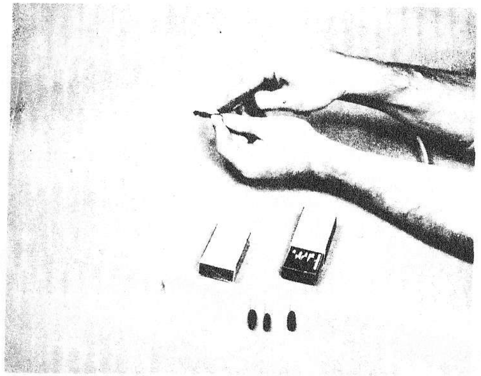


Figure 16

c. <u>Matches</u>

Any kind of match may be used to ignite safety fuse. The fuse should be split through the powder train at least one-half inch from the end, as shown in Fig. 17, and the match-head inserted so as to be in intimate contact with the black powder. The split ends of the fuse should then be folded around the matchhead, which is positioned so that a small portion of it protrudes. This facilitates scratching the matchhead against a box strikerboard in order to light the fuse.

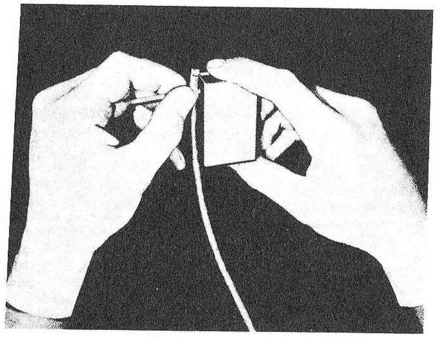


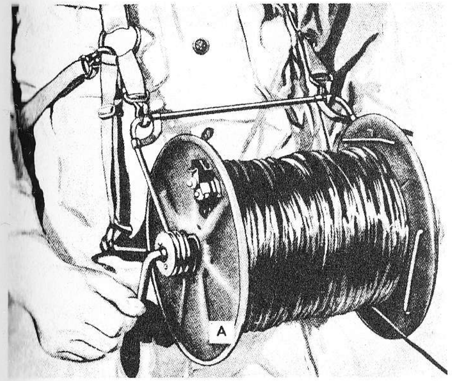
Figure 17

Igniting Fuse with a Match

B. Electrical Equipment

1. <u>Firing Wire</u>

Firing wire for electric firing of charges (see Fig. 18) is issued in 500-foot lengths. It is stranded, two-conductor, No. 18 A.W.G. plastic- or rubber-covered wire. The wire is carried on one of the two reels shown in Fig. 18. It may sometimes be necessary to use two 500-foot lengths of wire in order to reach a safe firing distance.



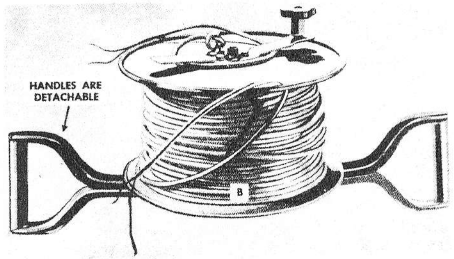


Figure 18

Firing Wire Reels

2. <u>Jumper Wire</u>

Jumper wire is single-conductor, No. 20 A.W.G. wire. It may or may not be enameled, but is covered with waxed textile or plastic. It is issued for making connections between adjacent electric caps which are too far apart to permit cap lead wire splices, or between firing wire and electric caps. It is issued in rolls of 100 and 200 feet.

3. <u>Galvanometer</u>

The galvanometer shown in Fig. 19 is used to test electrical demolition circuits. It contains an electromagnet, a small, silver-chloride dry cell, and an indicator scale and needle. (The dry cell does not put out sufficient energy to detonate standard electric caps.) When the terminals are joined by a closed circuit, the

electromagnet is energized, which causes the needle to move across the scale. Needle deflection should not be paid undue attention, since the condition of the battery influences any reading.

A new-type galvanometer is equipped with indicator lamp and a small, surge generator. If the lamp fails to flash when the switch or generator is operated, the wire circuit across its terminals is open.

Galvanometers must be handled with care and kept dry. Before being used, they are tested by holding a piece of metal across the terminals. If in operating condition, this will cause a wide needle deflection on the battery type and a lamp flash on operation of the switch on the generator type.

Dry cells cease to function at subzero temperatures. Only the special cell may be used in the galvanometer; other cells may be strong enough to initiate a detonator.

For instructions concerning the use of galvanometers see Section 7.

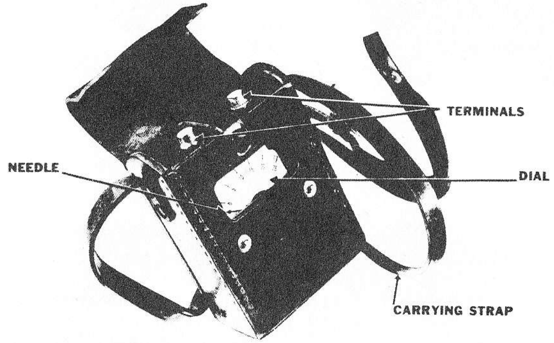


Figure 19

Galvanometer

4. Blasting Machines

Blasting machines (see Figs. 20 and 21) are used to generate the current necessary to fire explosive charges electrically. They are operated either by a quick twist of the handle in the hand type, or by a downward thrust of the handle in the ground type. These machines are rated according to the number of blasting caps they can be depended upon to fire in straight series. They are ruggedly built and with reasonable care will provide service for many years.

a. Hand-Type Blasting Machine

This machine (see Fig. 20) is designed to fire 10 electric blasting caps in series. It is equipped with detachable handle, hand strap, and knurled terminal taps. The machine should be exercised by a few vigorous twists of the handle before the firing wires are attached.

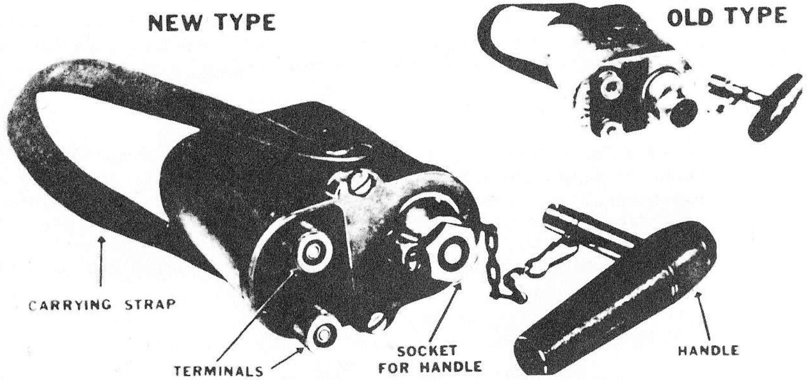


Figure 20

b. Heavy-Type Blasting Machine

These machines (see Fig. 21) are designed to fire their rated number of caps (20, 30, 50, or 100) in series. Their weight, 20 to 30 pounds or more, makes them unsuitable in most cases for sabotage operations. They are operated by a vigorous downward thrust of the handle.

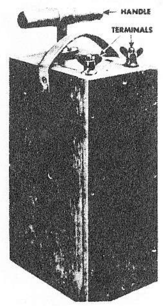


Figure 21

Heavy-Type Blasting Machine

C. Miscellaneous Equipment

1. Adhesive Compound

Adhesive compound is a sticky, puttylike substance issued for the attaching of charges to vertical or overhead surfaces. It will hold a charge in place from a few minutes to several days, depending on the weight of the charge and the condition of the surface to which it is attached. It will not adhere satisfactorily to dirty, wet, or oily surfaces. Its adhesive qualities are impaired by water and subzero temperatures.

2. Cap-Sealing Compound

Cap-sealing compounds are used primarily to moistureproof the connection between a nonelectric cap and a safety fuse. They are also used to seal exposed ends of detonating cord, to insulate electrical connections, etc. The most suitable type of sealing compound is a quick-drying, extremely viscous, rubber-based sealer. Suitable substitutes include rubber cement and paraffin wax.

3. Detonating Cord Clip

Detonating cord clips (see Fig. 22) are made of sheet metal and are used to connect two strands of detonating cord, either parallel or at right angles to each other, or to fasten a blasting cap to detonating cord. With these clips, strands of detonating cord can be connected with greater facility than would be the case if knots were used.

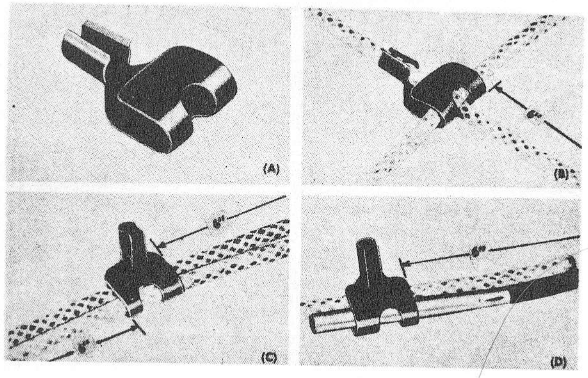


Figure 22. M1 Detonating-Cord Clip and Method of Use (A) Clip (B) Branch-line connection (C) Splice of two leads (D) Connection of cap to lead

4. Explosive Reamer

The explosive reamer (see Fig. 23) is used to make or enlarge a cap well in cast explosive blocks. It is made of nonsparking metal.

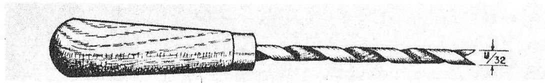


Figure 23

Explosive Reamer

5. Priming Adapter

Priming adapters (see Fig. 24) are threaded plastic plugs which are drilled and slotted to permit the priming of explosives equipped with threaded cap wells. The longitudinal slot permits the passage of electrical cap wires through the center of the adapter without a lengthy threading process. In priming nonelectric cap with safety fuse, the fuse must be inserted through the threaded end of the adapter, if the cap is already crimped. Caps should be positioned with wire or fuse end seated in the adapter before they are inserted in the cap well.

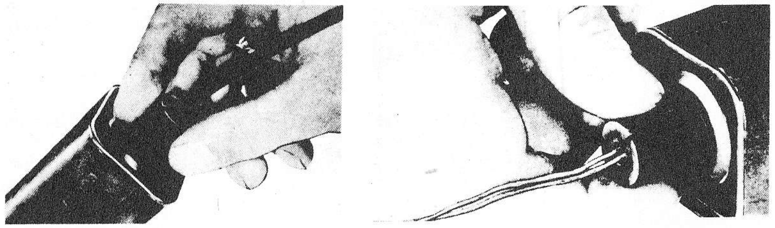


Figure 24. Priming Adapter (A) with nonelectric cap (B) with electric cap

6. Tape

Both adhesive and friction tape are suitable for demolition purposes. They are issued in rolls of various lengths and widths.

7. Twine

Any type of twine or cord similar to No. 18 hemp twine is suitable for demolition purposes.

SECTION 5. RULES FOR HANDLING EXPLOSIVES

Operational situations may prevent adherence to the suggested rules outlined below. Otherwise, the rules concerning the storage, transportation, and handling of explosives should be scrupulously followed.

A. Storage

Ideally, storage facilities should be burglarproof, bulletproof, lightningproof, and fireproof. Also, they should be of soft brick, hollow tile, or corrugated iron and should be weatherproof, dry, and well ventilated. Military-type explosive storage magazines are usually constructed just below ground level, and are revetted with earth.

Chart 2 gives the distances at which military-type magazines should be located from adjacent magazines, buildings, and routes of communication. This will afford a basis for establishing the dispersal requisites for temporary storage facilities.

Chart 2 Magazine Location

MAXIMUM QUANTITY OF EXPLOSIVE (in Pounds)	MINIMUM DISTANCE IN FEET FROM NEAREST			
	Inhabited Building	Public Railway	Public Highway	Magazine
50	145	90	45	60
100	240	140	90	80
2,000	1,200	720	360	230
25,000	2,140	1,290	640	300
100,000	3,630	2,180	1,090	400
250,000*	4,310	2,590	1,300	800
*Maximum permitted in any one magazine.				

Temporary storage facilities are selected to provide as many of the desirable qualities of the permanent facility as possible, with stress being placed on weatherproofness and ventilation.

B. Transportation

The transportation of explosives by rail or over public roads is closely regulated by all governments. When explosives are overtly

transported, the movement must be in accordance with local regulations. In general these prescribe load limits, types of permissible packaging, manner of loading and securing, dispersal from other hazardous cargoes, marking, etc.

In training areas, motor vehicles used to transport explosives should be appropriately marked on all sides.

If possible, blasting caps should not be carried aboard a vehicle transporting other types of explosives. When the two must be transported together, they should be separated from one another as far as possible.

It is needless to stress that drivers should obey all traffic regulations and avoid congested areas while explosives are being carried.

C. Safety Precautions

Observance of the following rules will minimize the possibility of accidentally caused fires and explosions:

Never fail to post safety rules for transportation, storage, and handling of explosives in a conspicuous place within the storage facility.

Never leave explosives unguarded. Keep them under lock and key.

Never handle explosives carelessly.

Never smoke near explosives.

Never permit open lights or other flame in or near explosives.

Never allow leaves, grass, brush, etc., to accumulate around a storage facility.

Never store metallic tools and miscellaneous materials with explosives.

Never wear shoes with exposed nails or cleats inside a storage facility.

Never fail to issue older explosives first. Arrange explosives so that old stocks will be accessible.

Never permit cases of explosives to rest on the floor. Place them on pallets so that air may circulate about them.

Never open cases of explosives within or too near to a storage facility.

Never open cases of explosives with a sparking tool. Use a crimping tool, wooden mallet, and wooden wedge.

Never assemble explosive primers in a storage facility.

Never store safety fuse near oil, gasoline, kerosene, or similar solvents.

Never store blasting caps in the same container or facility with other explosives.

Never forget to turn cases of dynamite every 30 days. Write on the case the date on which the explosive is turned.

Never store dynamite so that cartridges stand on end.

Never use frozen dynamite. Thaw it as described in Section 2.

Never use explosives that have obviously deteriorated. They should be destroyed as outlined in Section 6.

Never abandon any explosive.

Never carry loose blasting caps in the pockets.

Never insert a wire, nail, or other implement into the open end of a blasting cap.

Never leave blasting caps or other explosives exposed to the direct rays of the sun.

Never pull the wires of an electric blasting cap.

Never handle safety fuse carelessly in cold weather. Warm it before using.

Never crimp blasting caps with a knife or with the teeth.

Never forget to tape the junction of the cap and fuse, if the fuse is less than 1 foot long.

Never use electric blasting caps during the approach or progress of an electrical storm.

Never allow firing wire to remain open. Keep both wires twisted together at both ends except when splices and connections necessitate opening.

Never use electric blasting caps of different types and makes in the same circuit.

Never remove the short-circuiting shunt from an electric blasting cap until it is ready to be spliced into a circuit,

Never permit loose control of a blasting machine. The project leader should carry this during all projects.

Never use an unwaterproofed firing system underwater or in damp ground.

Never <u>force</u> explosives into a borehole. Make the hole larger.

Never tamp explosives with metallic implements. Use a wooden tamping rod.

Never attempt to light fuse by exposing a closed end to an open flame.

Never fire a blast until all surplus explosives are removed from the area.

Never connect a blasting machine to a circuit until the charge is ready to be fired. Remove it after the charge has been fired.

Never allow a blasting cap to be fired within 200 feet of unprotected individuals unless detonation occurs in a hole or depression.

Never hold a primer while lighting it. Place it on the ground.

Never spring a borehole near another that is loaded with explosive.

Never load a hot borehole. Cool it with water if necessary.

Never permit individuals to remain in the open when charges in contact with frangible materials are to be fired.

Never investigate a nonelectric misfire immediately. Wait at least 30 minutes.

Never divide responsibility for a demolition project.

D. Misfires

1. Causes

Generally speaking, a misfire is an explosive charge that has been initiated but, for one or more of the causes outlined below, fails to fire. Misfires are caused by:

Failure to ignite time fuse

Improperly made primers

Improper electric or nonelectric connections

Deteriorated fuse or explosive

Weak blasting caps

Damaged electric or nonelectric firing circuits

Improper operation of a blasting machine

Weakened blasting machine or other source of power

Use of different types or makes of electric caps in the same circuit.

Improperly balanced electric circuits (too much resistance for available power, etc.).

Care in placing charges, in assembling and placing primers, and in connecting firing circuits will eliminate many misfires. Dual firing systems practically eliminate the possibility of misfires.

2. Handling of Nonelectric Misfires

Unless there is positive evidence, i.e., the detonation of cap or caps alone, that the misfire was caused by a weak blasting cap, no nonelectrically primed charge should be directly approached. When possible, the investigation should not take place before at least 30 minutes have passed since the charge misfired. Charges that failed to detonate because of a weak blasting cap may be reprimed immediately.

Nonelectric misfire charges should be initiated by means of a long misfire-priming pole (see Fig. 25), especially if they are in contact with frangible material. The misfire should be approached

by the most sheltered route available. The long pole will permit the misfire primer to be placed within an inch of the misfire charge from a distance. The misfire should not be disturbed. Misfire primers should consist of a minimum of one-quarter pound of explosive.

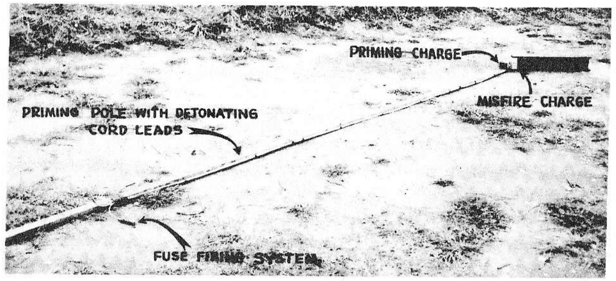


Figure 25

Borehole or otherwise tamped misfire charges should be fired by a larger primer (containing a minimum of 2 pounds of explosive) which must be placed within 1 foot of the misfire. Care must be exercised while the tamping material is being removed in order that the misfire not be unduly disturbed. After the new primer is emplaced, the tamping material should be replaced.

When detonating cord is used as a primer and fails to fire, it should be cut between the unfired blasting cap and the charge without unduly disturbing the cap. A new firing system should then be attached. If one or more detonating cord branch lines fail to detonate, separate firing system(s) should be attached.

If a detonating cord priming knot detonates but fails to detonate the explosive mass of which it was a part, the scattered explosive should be assembled and the mass reprimed.

A single blasting cap which has misfired should be fired with a blasting cap primer placed in contact with the unfired cap. If more than one blasting cap has misfired, a $\frac{1}{4}$-pound primer should be used to detonate the misfired caps (see Section 6. B.).

3. Handling Electric Misfires

Misfires of electrically primed charges may be investigated and corrected immediately, except when they are employed in combination with nonelectrically primed charges. When combination systems exist, resulting misfires must be handled as nonelectric failures.

Following a failure, it is natural to assume that the trouble lies in the electrical circuit rather than with the explosive charges. The circuit should be disconnected from the source of power and retested. Defective equipment may be immediately replaced.

E. Damaged Explosives

It is imperative that damaged or otherwise unsuitable explosives resulting from misfires, poor storage conditions, etc., not be allowed to accumulate and/or be ignored for even short periods of time. Such indifference or carelessness might be the cause of a serious accident. Misfired explosives must be gathered together and immediately destroyed. Deteriorated explosives should be destroyed as outlined in Section 6.

SECTION 6. DESTROYING EXPLOSIVES

When explosives are no longer needed or when they obviously would fall into enemy hands they should be destroyed.

A. Destroying Demolition Explosives

Most explosives, except blasting caps, may be destroyed by burning. The hazard of an explosion is always present, even under the most favorable conditions, so it is of prime importance to select a site where no damage will be done, either to persons or property, if the explosives detonate. This means a safe distance from any structure, railway, or highway, and any place where one or more persons may be even accidentally exposed to danger, including that from flying fragments.

Only one type of explosive should be destroyed at a time, and the utmost care should be taken to see that no blasting caps are accidentally included in explosives to be destroyed by burning.

Explosives should never be burned in cases or in deep piles. Instead, the cases should be opened and the explosive spread in a single layer on paper, excelsior, or other highly flammable material. No more than 100 pounds of explosive should be burned at any one time. A new space should be selected for each lot, as it is not safe to place explosives on ground heated by a prior burning.

No attempt should be made to return to the burning site as long as any flame or smoke can be observed.

Nitroglycerin explosives (dynamites) become increasingly sensitive as the burning temperature rises. When these explosives can be positively identified as being regular dynamites (see Section 2. C. 1. b.), 100 pounds may be burned at a time. If doubt exists as to whether an explosive is a regular dynamite or a blasting gelatin, it should be treated as the latter and burned in 10-pound lots.

Since some explosives are difficult to ignite, considerable kindling in the form of paper, wood shavings, sawdust, etc., should form a bed for the explosive. With some types of dynamite it may be necessary to pour kerosene over the cartridges in order to assure ignition. The explosive should never be directly ignited. Ignition of the flammable bed will permit the person burning the explosive to withdraw to a safe position before the fire reaches the explosive.

All explosives are extremely sensitive to shock at high temperatures. It is, therefore, important that no one poke about unburned explosives or the ashes until they are entirely cooled.

When an explosive has been burned, it is good practice to have the ground plowed, as the residue remaining may contain salts attractive but poisonous to livestock and wildlife.

Detonating cord should not be burned on spools. Rather, cut lengths should be spaced 1 inch apart atop the bed of flammable material.

Soluble explosives such as black powder and ammonium nitrate may be disposed of by pouring them in water after their wrappers have been removed. When ammonium nitrate is mixed with an insoluble explosive it should not be placed in water. It may be detonated or it may be burned after the container has been opened and the contents spread on flammable material. If black powder is burned it should be removed from containers. Extreme care must be exercised in order that ignition does not take place while the disposal crew is in the burning area.

Deteriorated explosives may be, and often are, more dangerous to handle than explosives in good condition. Only persons with considerable explosives experience should attempt to handle deteriorated nitroglycerin explosives, azides, fulminates, picrates, or unidentified explosives.

CAUTION: <u>The cautious manner in which deteriorated explosives are first handled must continue throughout the disposal project. The natural tendency is to become too confident following initial success; this often leads to serious accidents.</u>

Deteriorated explosives should be burned on a bed of flammable material in lots which do not exceed 10 pounds.

Explosives containers -- wooden cases and cardboard cartons and their paper liners -- should not be used as kindling materials. Rather, they should be considered to be explosive and destroyed accordingly.

Floors (concrete, wood, earth, etc.) with which ingredients of deteriorated explosives have come into contact must be considered to be hazardous. Flame or mechanical shock may cause an explosion. Nitroglycerin stains should be broom-scrubbed with a solution composed of $1\frac{1}{2}$ quarts of water, $3\frac{1}{2}$ quarts of denatured alcohol, 1 quart of acetone, and 1 pound of sodium sulphide (60-percent commercial). A solution of lye, alcohol, and water may also be used as a decontaminant. Sweepings should be considered explosive and destroyed accordingly.

B. Destroying Blasting Caps

Blasting caps which must be destroyed should be detonated in lots of 100, under confinement. The leg wires of electric caps should be cut off 1 inch from the cap before it is destroyed. Destruction of the caps should be carried out in the following manner:

1. Place the container of caps at the bottom of a shallow borehole.

2. Place a priming charge of one-half pound of explosive on top of the container.

3. Place a piece of paper or cloth on top of the priming charge. (This prevents the sand or soft earth tamping which is used to close the borehole from sifting down and forming a barrier between the priming charge and the caps.)

4. Detonate the priming charge.

5. After the explosion, carefully examine the ground around the borehole for unexploded caps.

Deteriorated caps include those which have been or are thoroughly wet or which are corroded. All such caps should be destroyed in the manner described above. <u>Corroded caps may be very dangerous to handle, and should only be handled by experienced personnel.</u>

SECTION 7. PREPARATION OF EXPLOSIVE CHARGES

A. General

Explosives are initiated by primers. High-explosive primers consist of those units of an explosive charge to which a blasting cap is directly connected. Low-explosive primers consist of safety fuse or some other spark-producing igniter, and that part of the charge to which the igniter is affixed. The process of assembling the explosive and blasting cap or igniter into a single unit is called priming. To prime a case of TNT, only one primer is required. This may consist of a single 1-pound block into which a fused blasting cap is inserted. Upon detonation of the primer, a shock wave is transmitted through alternate layers of cardboard and air to the surrounding explosives--it strikes these explosives with sufficient shock to cause detonation. The shock wave may be transmitted through any medium (air, soil, water, etc.) and may induce detonation where considerable gaps between primer and other explosives exist (i.e., the detonation of a $\frac{1}{2}$-pound block of TNT will usually cause the detonation of another block located 1 foot away). The phenomenon of detonation induced by the shock wave emanating from nearby explosives is termed propagation, or sympathetic detonation.

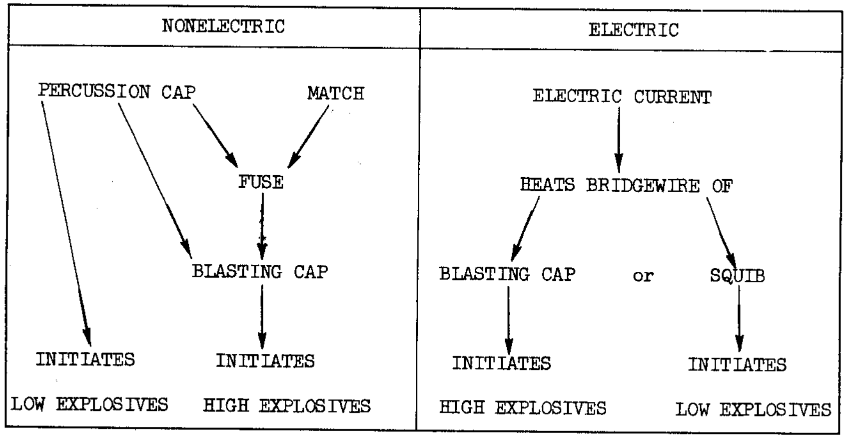
There are a number of priming techniques outlined below. All primers must be properly assembled and properly placed with respect to the remainder of an explosive charge, if misfires and associated delays are to be avoided.

An explosive charge may be assembled to fire electrically or nonelectrically (see Chart 3). There are certain advantages and disadvantages inherent in each technique. Active resistance activity requires considerable outside support, and in many cases operations are limited to the type of items thus received. For this reason, the field must be prepared to function with either electric equipment or nonelectric equipment. A discussion of the pros and cons of electric and nonelectric equipment follows.

The most distinct advantage of electrically primed charges is that misfires may be immediately investigated and cleared. (In training exercises, explosive charges in contact with frangible materials such as steel, concrete, etc. should be electrically primed whenever possible in order to minimize misfires and accidents.) On the other hand, electric equipment is bulky. Moreover, for multiple charges, considerable placing time and an understanding of electrical theory are required.

Nonelectric equipment is less bulky and requires less placing time and knowledge than the electrical equipment. The principal disadvantages of nonelectric materials include the misfire hazard and susceptibility to moisture damage. These are minimized by proper care and storage, as well as by the application of recommended techniques.

Chart 3. Chain of Action in Initiation of Explosives



B. Nonelectric Priming and Associated Techniques

1. High Explosives

The equipment necessary for nonelectric priming is discussed in relation to its comparative utility.

a. Firing Systems

A firing system comprises those parts of a primed explosive charge which collectively provide for initial ignition, delay, and detonation, i.e., (1) a match, time fuse, and blasting cap or (2) a mechanical, chemical, or electrical fuse with blasting cap (see Chapter II.).

(1) Safety Fuse Firing System

Safety fuse, blasting cap, and fuse lighter are necessary to assemble the firing system.

The only method of positively identifying safety fuse is to burn a length of it.

Safety fuse is extremely susceptible to moisture damage; therefore it is always advisable to discard that part of the fuse which has been exposed, i.e., the 3 inches at the end of the roll. Fuse should be square cut with a dry crimper or knife. Fuse is prepared for insertion in the cap by straightening the curl of the fuse and reducing its end diameter by rolling it between the thumb and forefinger (this also prevents frayed cords at the end of the fuse from interfering with insertion of the fuse into the cap).

A blasting cap should be inverted when it is removed from its container, in order to permit any foreign matter which may be in the cap to fall out.

To attach a blasting cap to a fuse, grasp the fuse about 2 inches from the prepared end and insert the prepared end in the blasting cap. Next, holding the cap and fuse so that the top of the cap is up and the fuse is vertical to the ground, allow the cap to position itself on the fuse. When the cap is positioned, lightly place the index finger of one hand over the junction of fuse and cap opening (see Fig. 26). (The third and fourth fingers of the hand may then be used as guides, making it possible to crimp the cap to the fuse in total darkness.) Next, crimp the cap to the fuse at a point near the open end of the cap, keeping in mind that a crimp on or too near to the explosive end of the cap may cause the cap to detonate. (If the safety fuse is less than 12 inches long, wrap a piece of tape around the junction of cap and fuse where the cap has been crimped to the fuse; some crimping tools leave a gap between cap end and fuse, and the tape will prevent a spark from the igniter from entering the cap through such a gap.) The fuse lighter should not be connected to the fuse until shortly before the charge is exploded.

(2) Instantaneous Firing System

Sabotage and guerrilla operations often require split-second timing--for example, in ambushes or train derailments. Nonelectric, instantaneous firing systems suitable for such operations are discussed in Chapter II.

(3) Delay Firing System

Nonsmoking, silent delay firing systems are described in Chapter II.

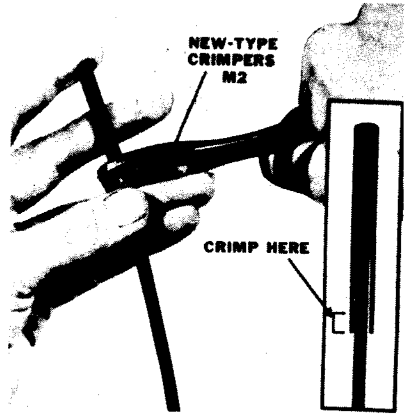


Figure 26

Crimping Technique

b. Assembling Blasting Cap Primers

All explosive primers must be assembled with the firing system securely fixed to the explosive. This serves to minimize training and operational failures caused by carelessness, excitement, etc.

(1) Cast Explosives

The priming adapter (see Fig. 24) assures a firm connection of firing system and explosive. It may be used with those explosive blocks and charges equipped with the threaded cap well.

When priming adapters are not available or when explosives which do not have threaded cap wells are used, cord or tape is used to secure the firing system to the charge (see Fig. 27). Wrap the cord tightly around the block and tie it securely over the cap well, leaving several inches of cord after the tie is made. Move the cord to one side and insert the cap. Secure the firing system by making a tie around the fuse.

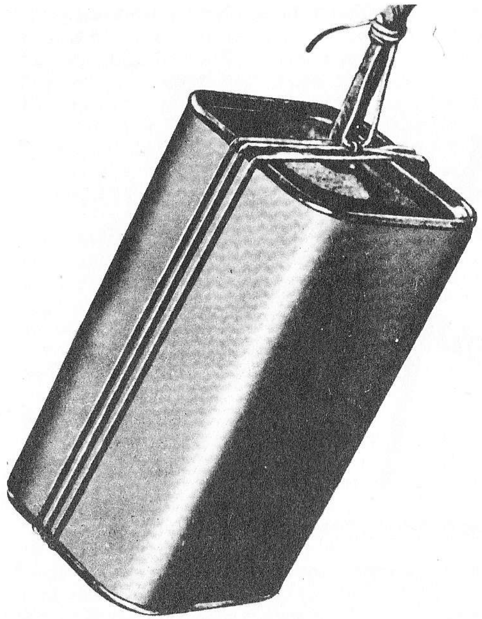


Figure 27

(2) Plastic Explosives

Plastic explosives are primed as is shown in Fig. 28. The cap is positioned so that a $\frac{1}{2}$-inch peripheral mass exists along its longitudinal axis, with the closed end about 1 inch inside the mass. The cap recess may be fashioned with a crimper punch or wooden stick. After insertion of the blasting cap, the mass must be firmly squeezed in order that the explosive be in intimate

contact with the cap. Failure to do this may cause a misfire or low-order detonation. For purposes of utility, i.e., priming, placing, etc., it is recommended that operational charges of plastic explosive be prepared and packaged as outlined in paragraph B. 3. b. of this Section. Plastic explosives become very soft when exposed to high temperatures, and therefore must be packaged if they are to maintain a definite shape. Plastics become hard and brittle at low temperatures and may be softened by warming the explosive by body heat or warm water.

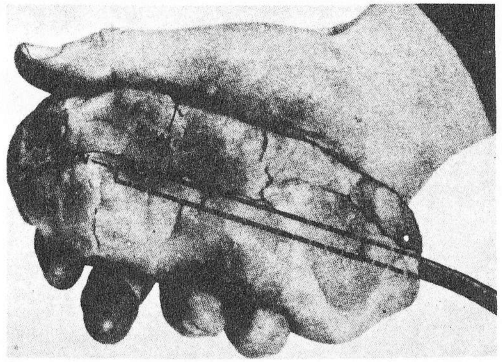


Figure 28. Position of Blasting Cap in Plastic Type Explosive

(3) Cratering Charge

The ammonium nitrate cratering charge should always be double-primed when used in boreholes. This is recommended to minimize misfires, which, since the charges are buried, are difficult to deal with. It is advisable to use primacord or electrical priming for multiple borehole charges in order that detonations occur simultaneously. The cratering charge shown in Fig. 29 is single-primed. Notice that the firing system is secured to the cleat between the cap well and primacord tunnel. A second primer, a $\frac{1}{2}$-pound charge, should be placed opposite the center band before the borehole is closed. When firing systems are used underground, they must be waterproofed. When boreholes are closed, care must be exercised so that stones and tamping tools do not damage the fuse or charge.

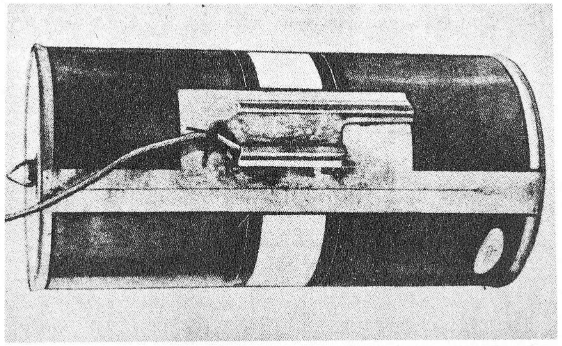


Figure 29

Cratering Charge Primed Nonelectrically

(4) Dynamite

Dynamite is primed by fashioning a cap well in the cartridge with a crimper punch or a wooden stick, inserting the blasting cap, and securing the fuse to the cartridge with cord. The cap recess may be punched at one end of the cartridge or in the side of the cartridge.

(a) End Priming (See Fig. 30)

Punch through the paper and into the cartridge to a depth greater than the length of the cap being used. Insert the cap end of the firing system and secure with cord. (An alternate end-priming technique is shown in Fig. 31; this is used when the paper is difficult to punch through.) Unfold the paper from the cartridge end before fashioning the cap well. After inserting the cap, fold the paper tightly around the fuse and secure with cord.

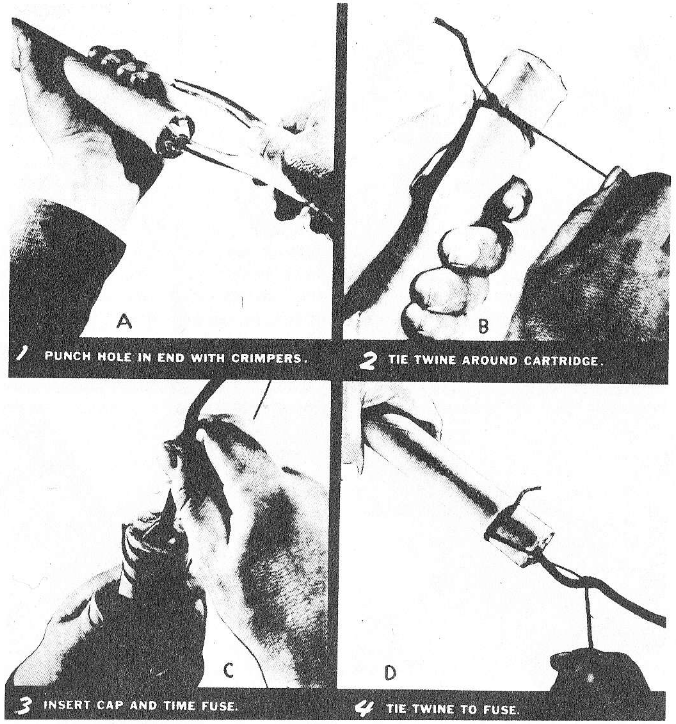


Figure 30. End Priming Dynamite Cartridge

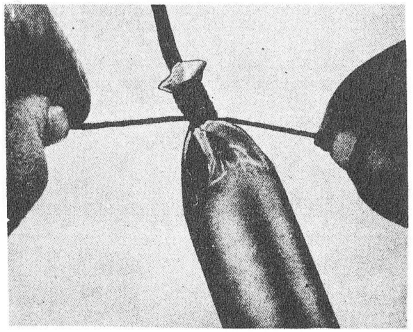


Figure 31. Alternate End Prime for Dynamite

(b) Side Priming (See Fig. 32)

Force the punch diagonally through the paper, about 2 inches from the end of the cartridge, and into the explosive so as to recess as close to the core of the mass as possible. Make sure the depth of the recess is greater than the length of the cap being used. Broaden the recess as the punch is being withdrawn. Insert the cap and secure the fuse firmly with cord. This primer may be moistureproofed by wrapping cord closely about the cartridge to a point an inch above and below the cap recess and then applying waterproofing material over the wrap.

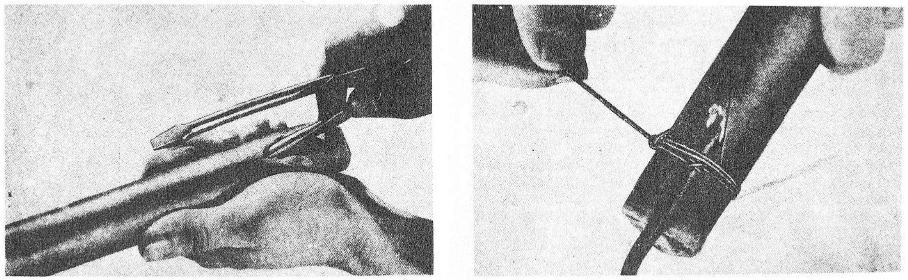


Figure 32. Side Priming Dynamite Cartridge

c. <u>Priming with Detonating Cord</u>

When one end of a length of detonating cord is properly wrapped about or otherwise attached to an explosive charge and a firing system is fixed to detonate the detonating cord, the primer is complete.

All packaged explosives may be primed by tying detonating cord with two half hitches, with an extra turn between them around the mass (see Fig. 33). These three turns must be in contact and must fit snugly against the block.

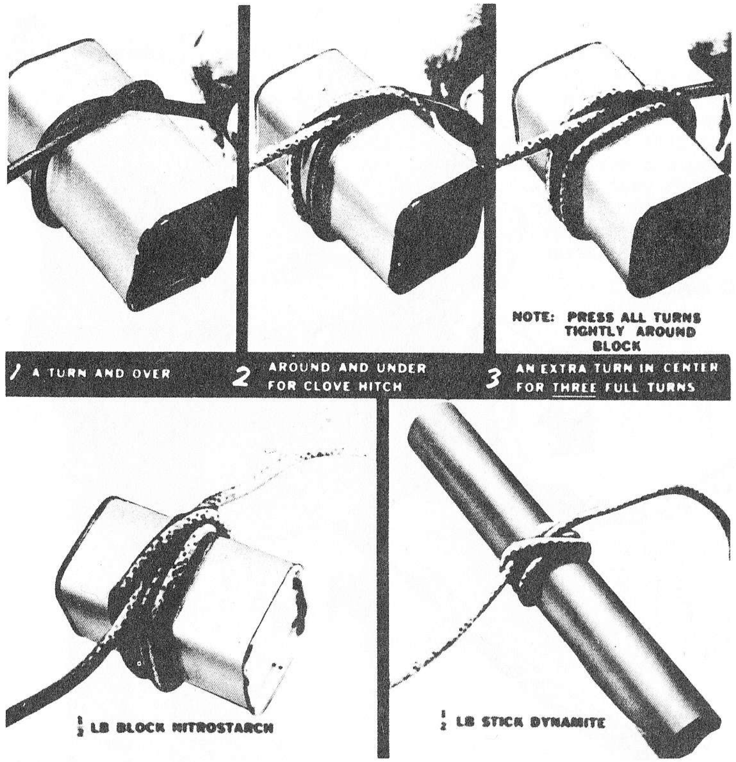


Figure 33

The 1-pound nitrostarch block may be primed by threading a single strand of detonating cord through diagonally opposite cap recesses and knotting the short end (see Fig. 34).

The ammonium nitrate cratering charge is half primed by threading one end of a single strand of detonating cord through the tunnel and is secured by an overhand knot (see Fig. 35). The cratering charge should always be double-primed when used underground.

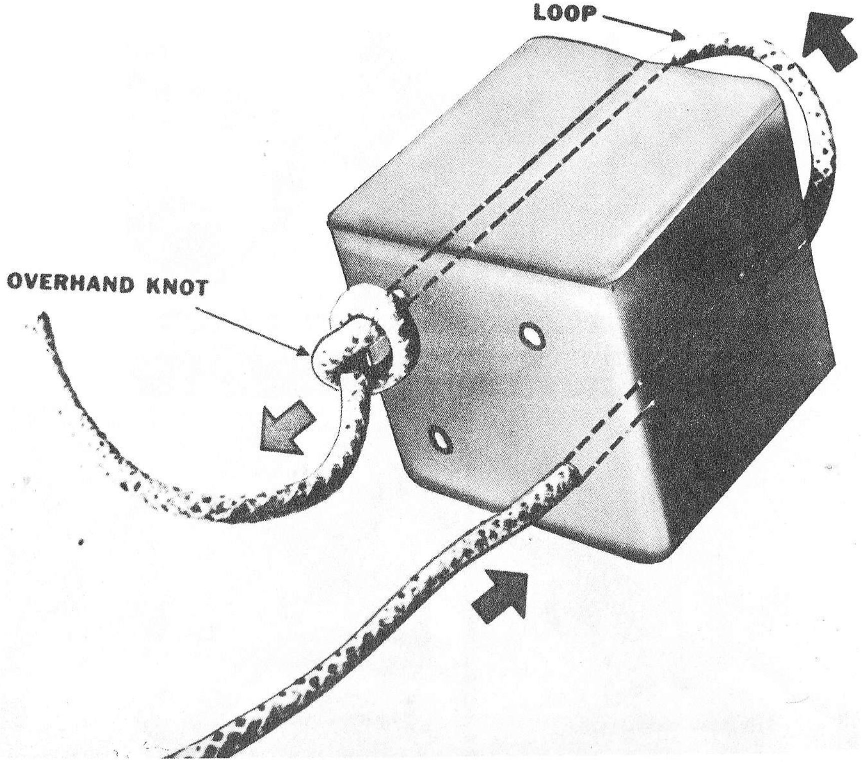


Figure 34

In each of the above cases, the end of the cord associated with the charge must be free, and should be 6 inches long, as is shown in Figs. 33, 34, and 35. This is necessary because, due to the capillarylike action of the fuse core, susceptibility to atmospheric moisture extends to a point 6 inches from an open end.

Various detonating cord priming knots (see Fig. 36) are often used for priming plastic explosives. The 6-inch, moisture-contaminated ends must not be tied into the knots themselves; they should be doubled back as shown in Fig. 36 or be cut off and discarded. The triple roll priming knot (see Fig. 37) is

considered the most suitable because of its explosive concentration and compactness. It is tied as shown in Fig. 37. The position of the knot must generally be as is shown in Fig. 38 A. If the knot is improperly placed at the center of the mass, as is shown in Fig. 38 B, a low-order detonation is likely to result. This is because the shock emanating from a single lead-in strand of detonating cord is less than that required to detonate the explosive consistently. Remember that the detonating wave proceeds through an explosive from the point of initiation, in this case the point at which the detonating cord lead-in strand contacts the explosive.

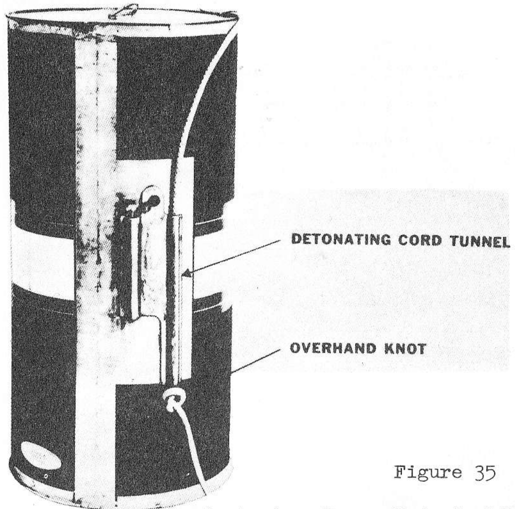


Figure 35

Cratering Charge Primed with Detonating Cord

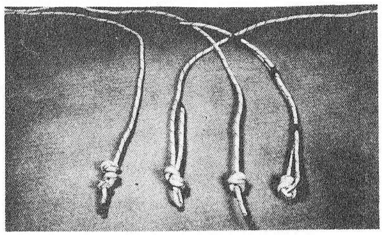
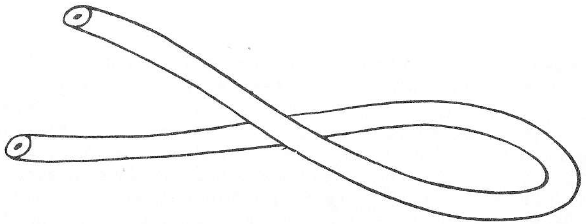


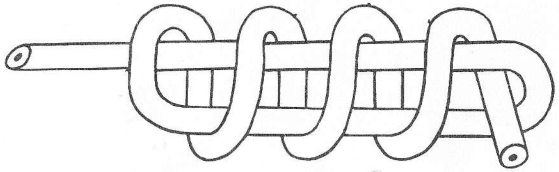
Figure 36

A



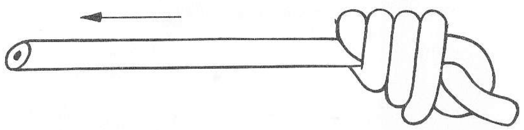
Step A BEGIN. Leave a 6" tail.

B



Step B WRAP. Wrap as tightly and as close together as possible

C

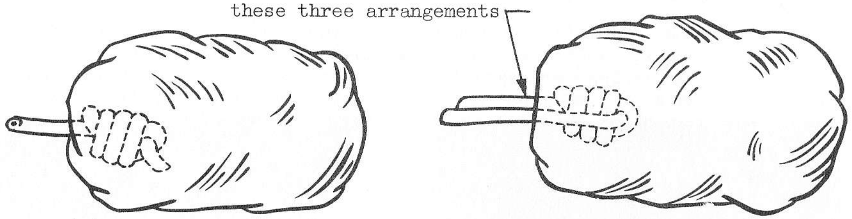


Step C TIGHTEN. Pull Tight.

Figure 37. Method of Tying Triple-roll Priming Knot

Priming is completed by affixing the firing system to the detonating cord with tape, wire, or cord (see Fig. 39). Notice that the closed end of the cap faces toward the explosive charge. To facilitate the attachment of the firing system, the 6-inch tail of the detonating cord is doubled back to form a trough into which the cap is laid. Taping should proceed from the fuse end of the cap and continue forward to the explosive end. The cap must be in intimate contact with the detonating cord, with no layer of tape or other material between the two, if positive detonation is to be assured.

A CORRECT PRIMING: A high-order explosion will be initiated by any of these three arrangements



(a) Triple roll tie knot in block

(b) Double strand with knot in block

B INCORRECT PRIMING: A low-order explosion will occur at the 1st point of contact

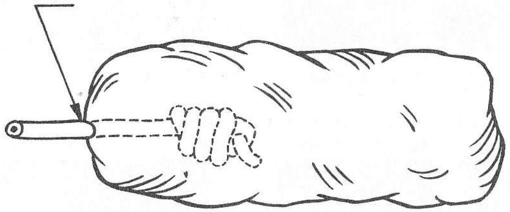


Figure 38. Position of Priming Knot in Plastic Explosive Charges

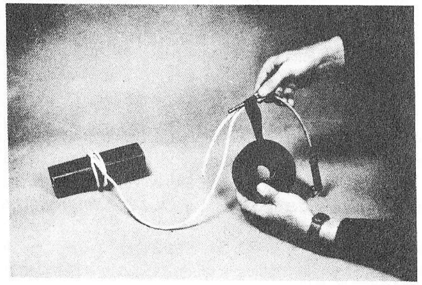


Figure 39

d. Waterproofing Firing Systems

When explosive charges are used underwater or in extremely damp areas, their firing systems should be thoroughly waterproofed. Particular care should be taken to make all joints watertight, as a drop of water on the core of time fuse or on the blasting cap flash charge would cause failure. All charges should be dual primed.

(1) Waterproofing Match-Ignited Systems (See Fig. 40)

(a) Cut match box strikerboard to a size that can be inserted into a rubber balloon of suitable size. Round off the corners so as to remove all sharp projections which might pierce the rubber. Position the strikerboard at the bottom of the balloon.

(b) Isolate the strikerboard by twisting a string or rubber band around the balloon, as shown in Fig. 40 B. This serves as a safety loop.

(c) Split the fuse through the powder train so that the head of a match can be positioned as shown in Fig. 40 C. Insert the match end of the fuse in the balloon.

(d) Stretch the balloon as shown in Fig. 40 D and wrap tightly about the fuse. Do not relax tension until joint is locked with several turns of rubber band or twine.

(e) Apply wax or soap to the crimped junction of the blasting cap and fuse.

(f) Place the cap in a second balloon and seal as described above.

The waterproofed firing system should be linked to the charge in the usual manner. When cast explosive is used, it may be necessary to increase the diameter of the cap well to accommodate the thicknesses of rubber surrounding the blasting cap.

To operate the system, the safety loop should be removed. Hold the strikerboard with one hand and rake matchhead across it with the other. The match flash may break the balloon but this is unimportant, since the powder train will already have been initiated.

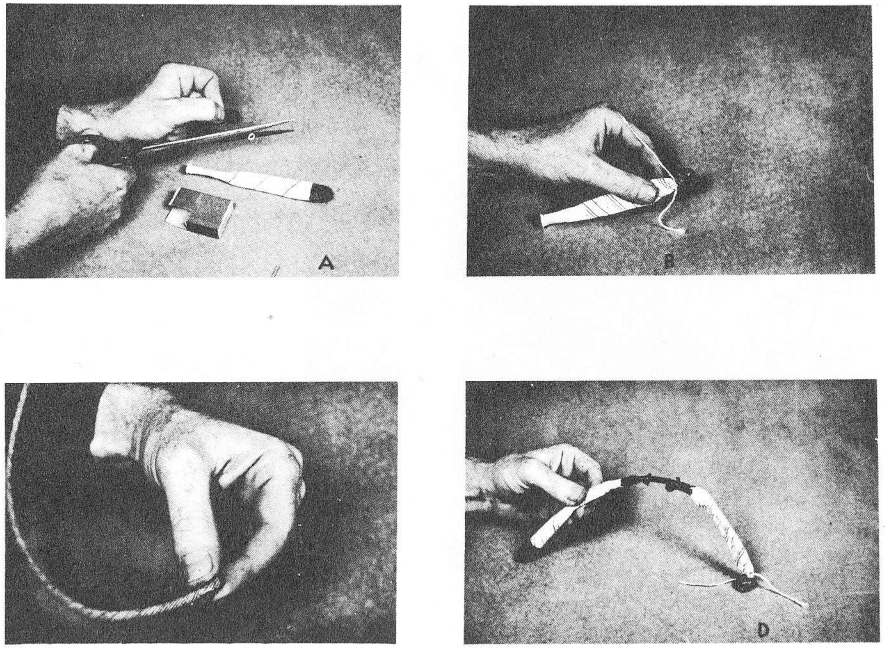


Figure 40

(2) Waterproofing Other Devices

Most mechanical-type fuse devices (see Chapter II.) may be used as safety-fuse igniters. These may be waterproofed by placing them inside a latex rubber sack or balloon.

2. Low Explosives (Black Powder)

An igniter takes the place of a blasting cap when deflagrating explosives are primed. Actually, a length of safety fuse might comprise the whole firing system for black powder, as is shown in Fig. 41.

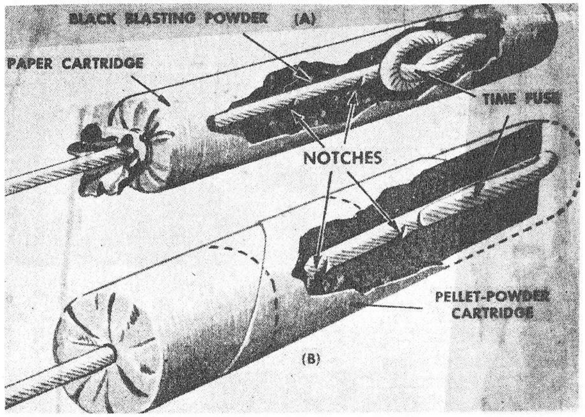


Figure 41

Black Powder Primed Nonelectrically

a. Granular Powder

Three inches of powder are poured into an improvised paper sleeve about the size of a dynamite cartridge. A series of notches about 2 inches apart which penetrate the powder core must be cut in the length of fuse being used as an igniter. An overhand knot tied at the end of the igniter fuse serves to anchor this firing system within the charge after the cartridge has been filled and closed (see Fig. 41 A).

b. Pellet Powder

Pellet powder is issued in standard-type paper-covered cartridges. Since the individual pellets are center-recessed, it is only necessary to punch through the paper wrapper at either end of the cartridge to insert the long, beveled end of a notched (with notches 2 inches apart) length of fuse. The fuse igniter is pushed through the cartridge far enough to permit about 2 inches of the beveled end of the fuse to be doubled back. As this loop wedge is pulled back into the cartridge it will bind, thus anchoring the igniter (see Fig. 41 B).

3. Prepared Charges

a. General

Whenever possible, operational charges should be made ready prior to the time of their placement. For instance, where guerrilla saboteurs might consider an attack on a distant bridge or tunnel, operational charges would normally have to be broken down to individual man-loads for transportation. During a halt in a final assembly area, the charges would be reassembled and the primer detonating cord leads installed. They would be tied, wrapped if necessary, and be equipped with rope ties, magnets, suction cups, poles, etc. to facilitate rapid placement (see Fig. 42).

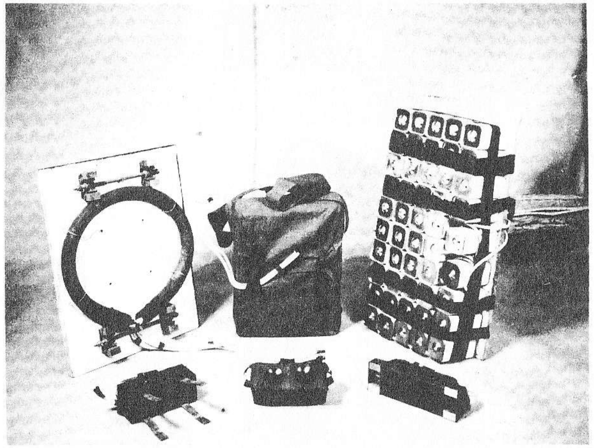


Figure 42

The cloth carrying bag in which some explosives are issued makes an ideal container for satchel-type charges.

To reduce the possibility of misfires, all charges should be doubled-primed. This is best accomplished with detonating cord. Two individual blocks are primed and then are placed with the remainder of the charge as is shown in Fig. 43.

To further guard against the possibility of misfires, dual firing systems should be used (see Fig. 44). This is also advisable in training situations where frangible materials and/or large charges are concerned.

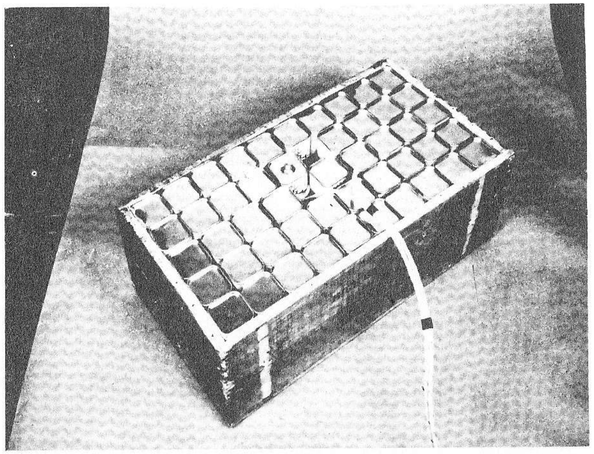


Figure 43

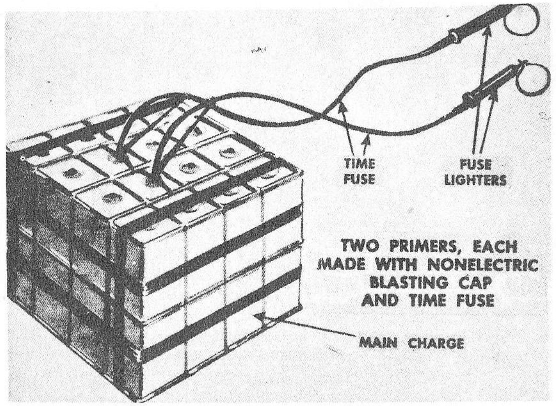


Figure 44

A nonelectric dual firing system for single charge

To attach a dual system to double strands of detonating cord, the fuses and caps are aligned and placed over the detonating cord as is shown in Fig. 45. Taping proceeds as for a single cap.

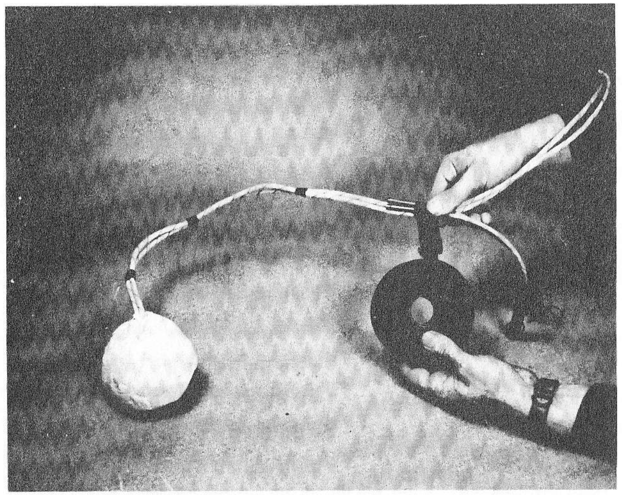


Figure 45

Although firing systems should be assembled prior to the placing of charges, they should not be connected to the charges until after the latter have been placed on the target.

Industrial sabotage would ordinarily require greater finesse as regards the form explosive charges would take. Fig. 46 gives examples of items that have been used to smuggle explosives into a factory or close to a specific target.

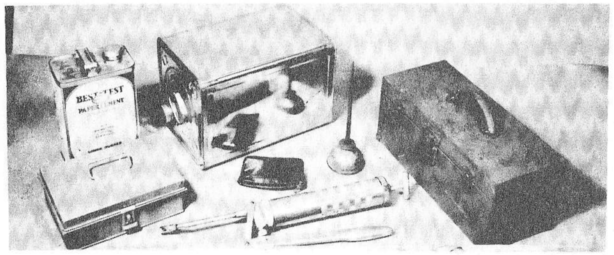


Figure 46

b. Standard Charges (See Fig. 47)

Plastic explosives are generally regarded as the saboteur's standard explosive. This is because of their great power and plasticity. Since many industrial machines and associated equipment are made of cast iron or thin steel, relatively small plastic-explosive charges are often capable of inflicting irreparable damage upon them. The standard charge described below is extremely versatile and is operationally suitable from the standpoint of size.

(1) A triple-roll priming knot or reasonable facsimile should be tied at the center of each of two 4-foot strands of detonating cord, as is shown in Fig. 47 A.

(2) Divide a $2\frac{1}{2}$-pound C-4 block (or $2\frac{1}{4}$-pound C-3 block) in half by cutting through the cardboard package as shown in Fig. 47 B.

(3) Remove the cardboard package after slitting or loosening the cemented overlap.

(4) Divide the half-block longitudinally, as is shown in Fig. 47 C.

(5) Press the detonating cord priming strands into each of the quarter-block slabs, offsetting each strand slightly (see Fig. 47 D).

(6) Put the quarter-blocks together so that a knot is at either end. Work the explosive so as to close internal cavities. Square corners are maintained by gently pounding the block on a flat surface (see Fig. 47 E).

(7) Fold the cardboard package about the block and cover the whole with tape, as is shown in Fig. 47 F.

(8) Secure the double strands of detonating cord with a turn of tape every 10 inches, as is shown in Fig. 47 G.

(9) Waterproof the open ends of the detonating cord and let them dry.

(10) Wrap the detonating cord tails around the charge and secure them in place with a turn of tape, as is shown in Fig. 47 H.

The procedure may be applied to the whole block if larger charges are required.

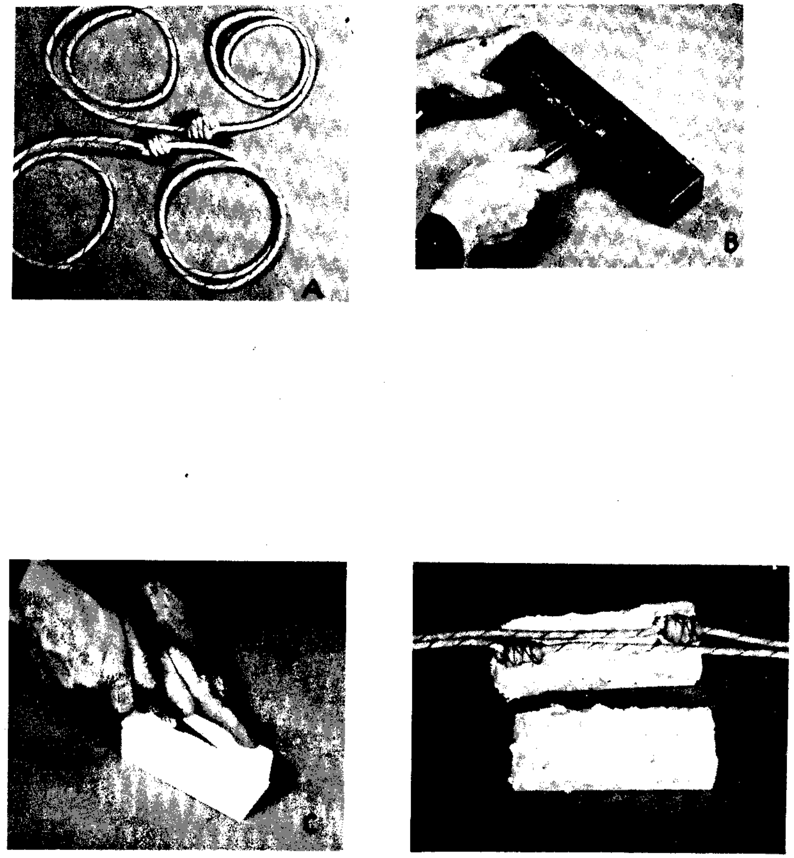


Figure 47 A-D

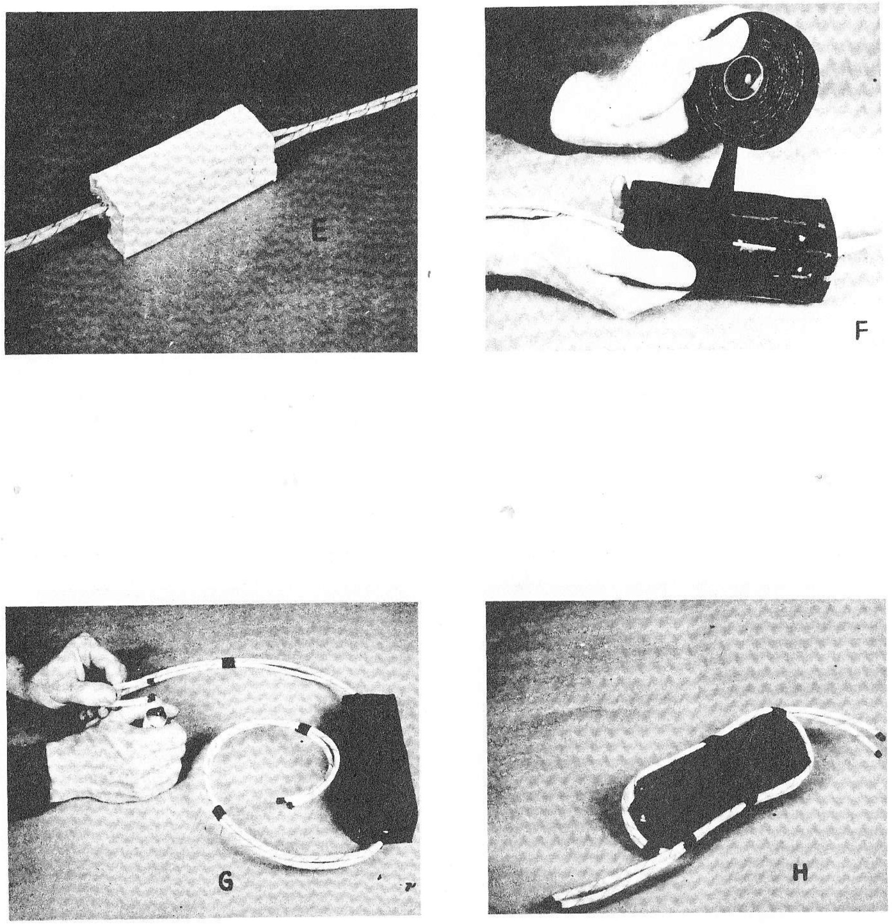


Figure 47 E-H

4. Detonating Cord Systems

Many demolition projects require the simultaneous detonation of multiple charges. Without detonating cord, this would be virtually impossible with nonelectric equipment.

The different systems suggested for linking multiple charges with detonating cord are designed to serve a variety of targets.

a. Straight Main (See Fig. 48)

The straight main is employed where the individual targets are in line, as with the target members on one side of a steel truss bridge or a single bank of transformers. While the main may consist of a single strand of detonating cord, this is not recommended, especially for operations, because of the possibility of misfire. Instead, the main should consist of two strands of detonating cord taped together at 10-inch intervals.

The main is laid as close along the line of targets as possible. The branch lines (the priming leads from individual charges) must approach the main line directly in such a manner that the angle formed by their junction will not be less than 90° on the side from which detonation proceeds (see Fig. 49). If this simple rule is violated, failures are likely to occur on the branch lines concerned. These branch lines will be severed at the point of contact with the main. Detonating cord might be described as being highly directional; the limited amount of explosive a strand contains almost precludes lateral propagation. If turns are necessary, sharp angles should be avoided in favor of gradual bends. If the main is primed from both ends, all main line branch line angles must be 90°.

Methods of tying and splicing detonating cord are described in paragraph e., below.

b. Ring Main (See Fig. 50)

The ring main may be employed to advantage where two generally parallel lines of targets are separated by considerable lateral distance, e. g., two transformer banks in a large electric power installation. Also, when the exact dimensions of a target facility are unknown, the ring main with standard charges is the more adaptable and economical technique to use.

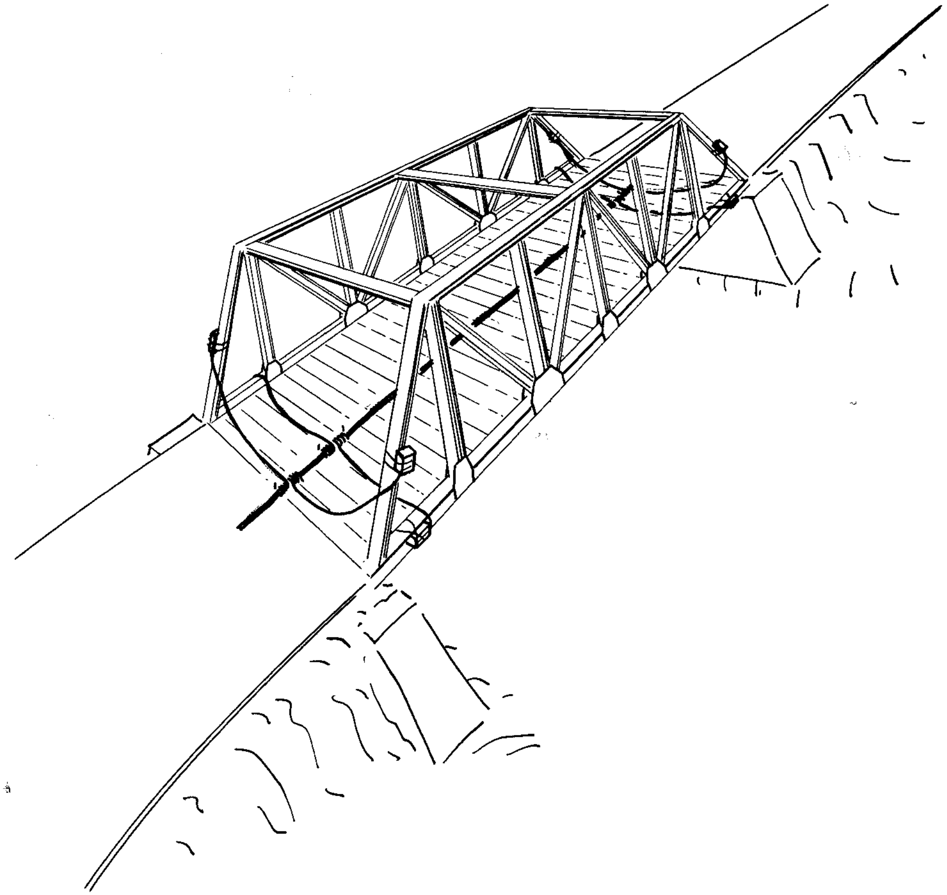


Figure 48. Straight Main

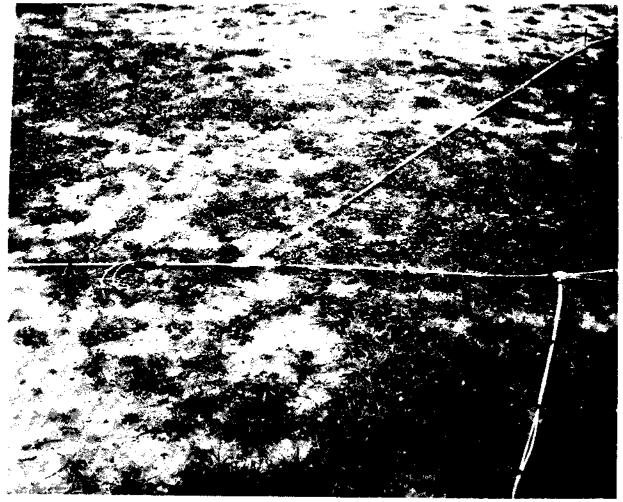


Figure 49

Branch line junctions, priming, etc. coincide with the principles outlined for the straight main.

c. Chain Main (See Fig. 51)

The demolition chain is used almost exclusively for the destruction of rail. The detonating cord tails of several standard-type charges are linked together or individual charges are fabricated on an unbroken strand of detonating cord, as with the M1 (tetrytol) demolition chain.

d. Junction Box (See Fig. 52)

The junction box is an arrangement that is usually employed where two closely placed charges must be detonated simultaneously, as would be the case for the bearing pedestals on either side of a generator, pump, etc.

e. Detonating Cord Connections

Detonating Cord Clip. The clip may be used to connect or prime single strands of detonating cord as described in Section 4. C. 3. Operational charges consisting of the recommended double-strand priming leads will not permit use of the clip. The simple knots described below will meet the double-strand requirements; they will also serve when clips are not available for single-strand priming.

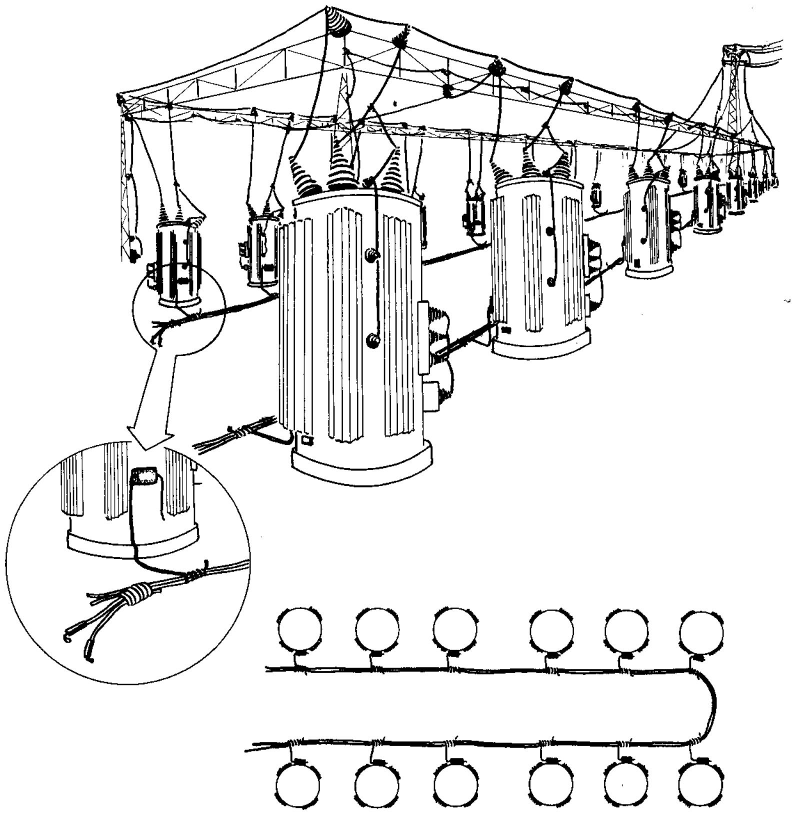


Figure 50. Ring Main

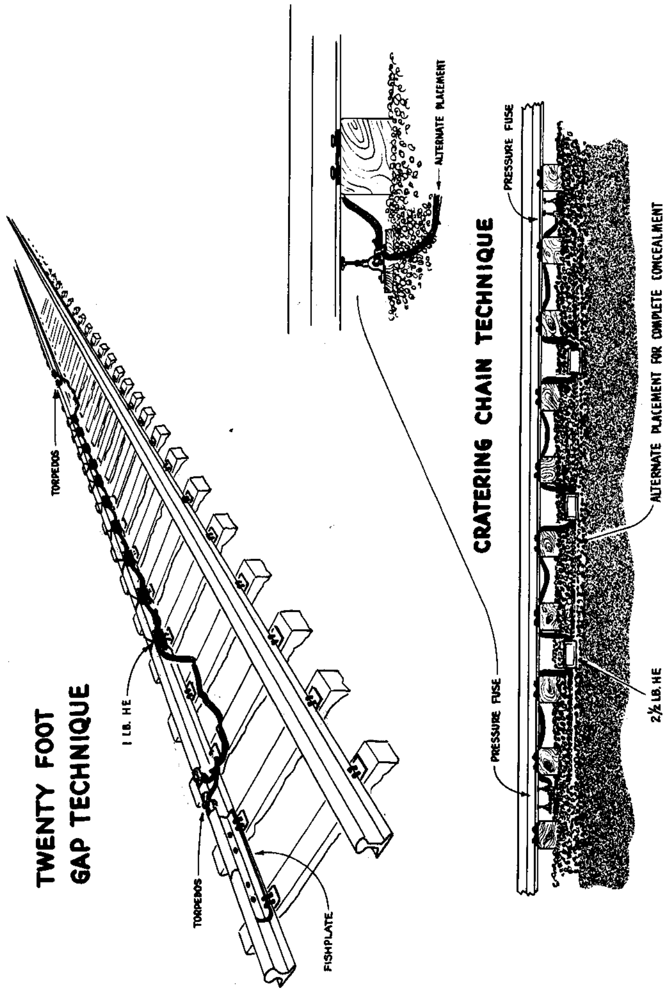


Figure 51

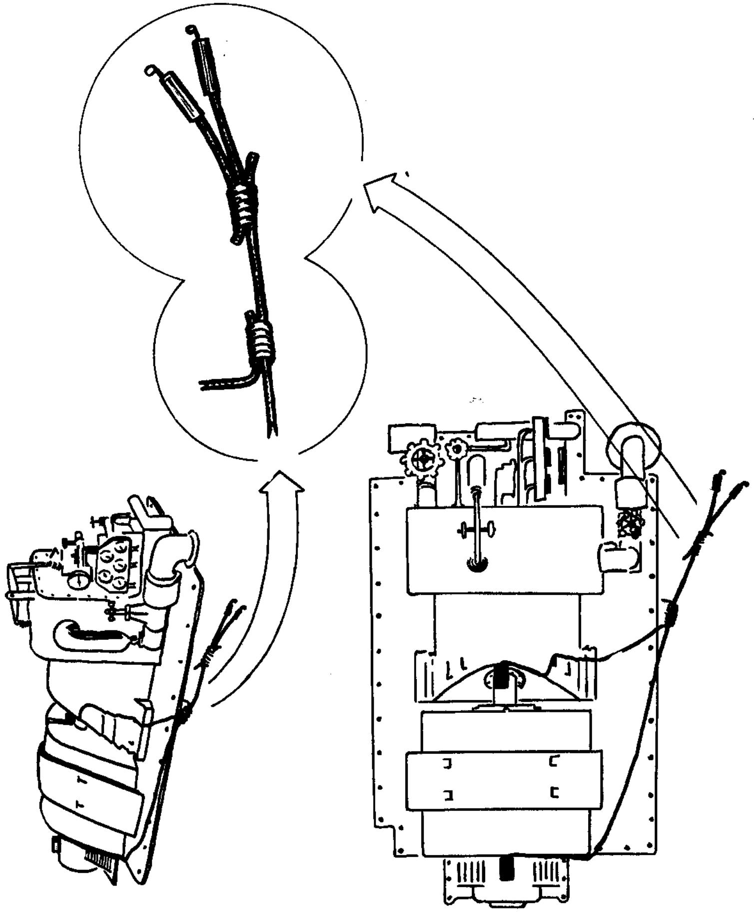


Figure 52. Junction Box

Triple-Roll Branch Line Knot (See Fig. 53). The use of the triple-roll branch line knot is recommended for all types of plastic-covered detonating cords. (Other knots tend to loosen due to the smooth and resilient character of the plastic.) This knot makes a satisfactory joint for double-strand detonating cord.

In tying the knot, the branch line-main line lock must be held until the tie is complete. Notice that the roll is secured by a single half hitch or with tape. If the branch line leads are sealed, there is no point in allowing for a 6-inch free tail.

Girth Hitch (See Fig. 54). The girth hitch may be used to connect single-strand, fabric-covered branch lines to the main line.

Notice that both this knot and the one described above are perpendicular to the axis of the main line.

Splices (See Fig. 55). Clips, square knots, and taped overlaps are used to join lengths of detonating cord. The clip may be used to splice single strands, as may the square knot for nonplastic-covered detonating cords. The taped joint best serves where plastics and/or double strands are concerned.

Firing Systems. Directions on how to prime with detonating cord in both single and dual firing systems have been given in paragraph B. 1. C. of this Section.

C. Electric Priming and Associated Techniques

1. General

Electric priming and firing techniques are widely used for industrial blasting and for military demolitions training. This is true because of the absolute firing control that electric equipment affords. Also, there is an economic advantage to electrical equipment where multiple charges are concerned, for jumper wire is far less expensive than detonating cord. Lastly, an electrically primed misfire may be cleared immediately, involving no risk to personnel, whereas the nonelectric misfire remains a hazard throughout the clearing procedure.

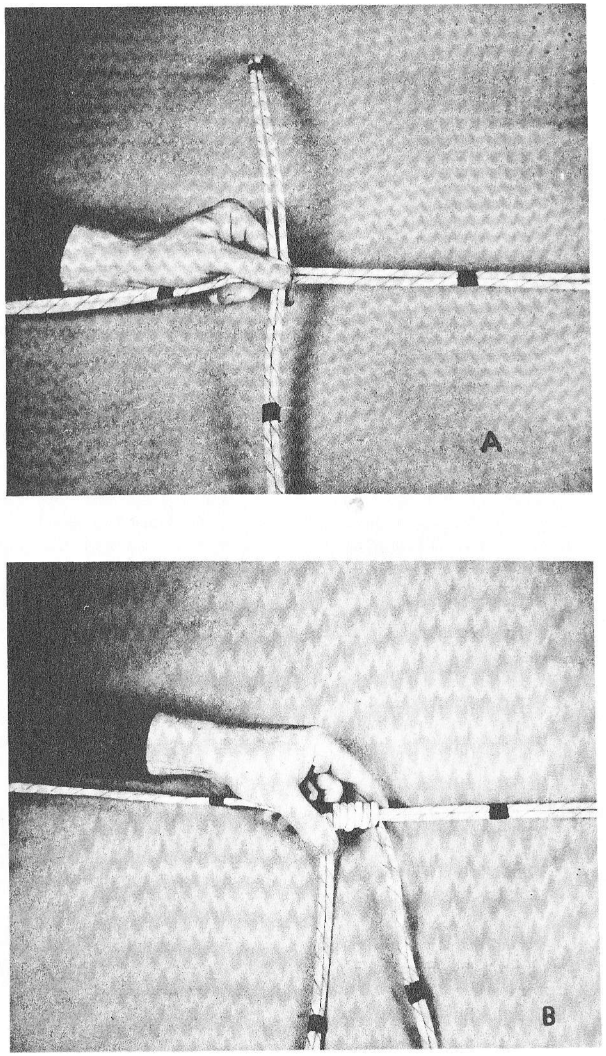


Figure 53. A-B

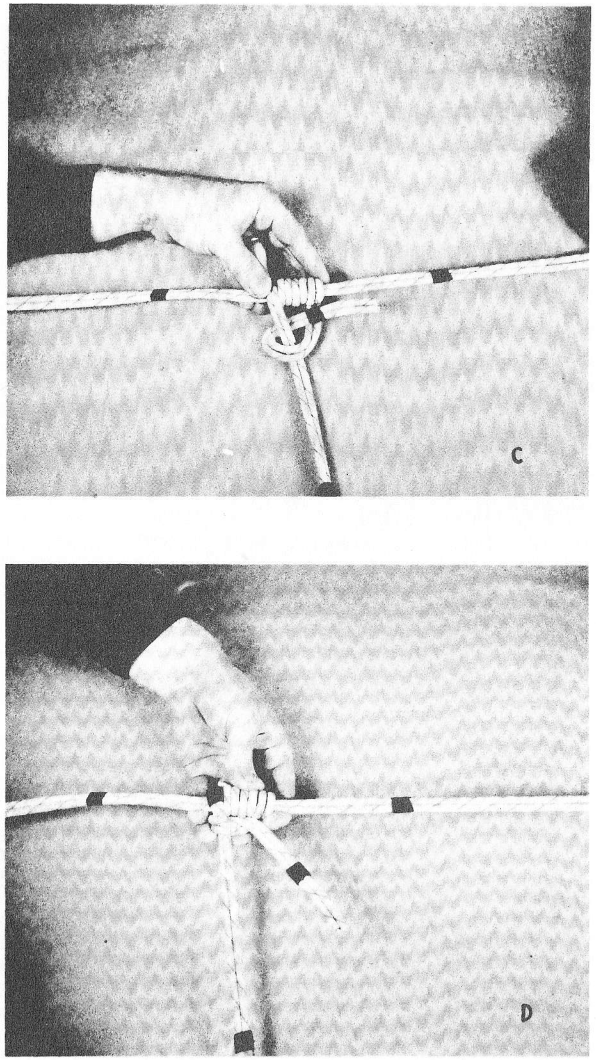


Figure 53. C-D

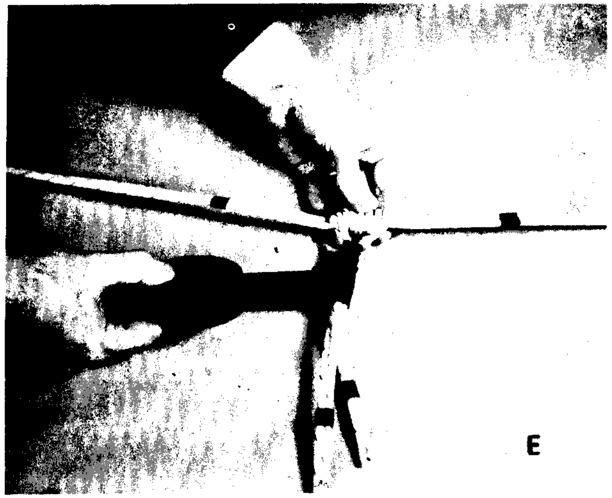


Figure 53. E

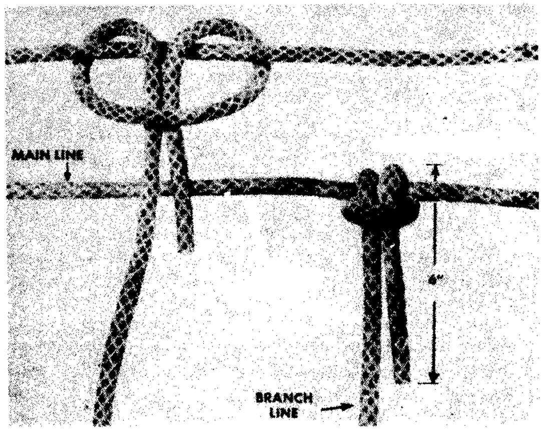


Figure 54. Method of Tying Girth Hitch

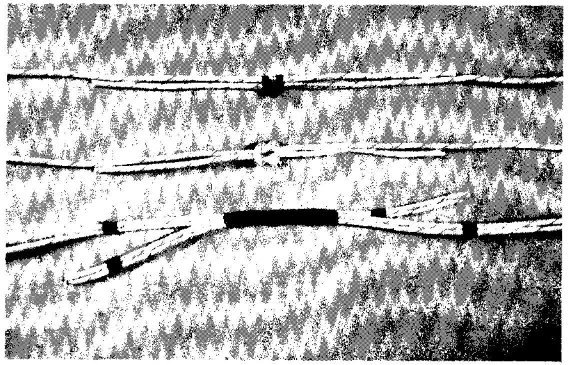


Figure 55

Because electric equipment is accepted over the nonelectric equipment for many industrial and training purposes is no reason to assume this should apply to sabotage operations. Blasters and trainees working under ideal conditions proceed as rapidly or slowly as necessary to set up their firing circuits correctly. The saboteur, on the other hand, may only have access to the target for the time it takes an enemy sentry to walk to and from the opposite end of his post. Furthermore, light conditions may be poor, and various forms of extraneous electricity (lightning, static electricity, radio-frequency energy, stray currents, etc.) may threaten not only the failure of the mission but also constitute a personal hazard if electrical equipment is being used. However, electrical equipment is well suited to a number of operational uses and may, therefore, be supplied to the field. Also, if equipment of this type is captured from the enemy, it is well to put it to use.

2. Assembling Electric Primers

a. High Explosives

The first step in priming an explosive charge electrically is to remove the cardboard shipping sleeve from the blasting cap and attached lead wires. Since the lead wires are accordion-folded, care must be taken to avoid tangling or kinking them as they are unfolded. The short-circuiting shunt should not be removed until the associated primer is completely assembled and is ready to be connected to the firing circuit. The procedure for electrical priming of high-explosive charges is identical to that of nonelectric priming so far as insertion of the blasting cap is concerned, the only exception being that the cap lead wires must be anchored to the primed charge with a girth hitch or similar tie, as is shown in Fig. 56.

This is advisable even if a priming adapter is used, for, without a tie, excessive strain on the cap wires might damage the cap firing element and cause circuit trouble or perhaps detonation. When plastic explosives are primed, the cap wires should be anchored to the target itself.

Priming charges linked with detonating cord are electrically complete after an electric blasting cap has been affixed to the detonating cord in the manner already described in Subsection B of this Section.

b. Low Explosives (Granular Powder and Pellet Powder)

An electric squib serves the same purpose as the safety fuse used in nonelectric firing of low explosives (see Subsection B of this Section).

(1) Granular Powder

Position the squib at the center of the cartridge, as is shown in Fig. 57 A.

(2) Pellet Powder

Punch a hole in each end of the cartridge. Push the electric squib completely through the cartridge and pull it out the opposite end. Reinsert it at the starting end of the cartridge and push it halfway through (see Fig. 57 B). Pull the leg wires tight.

3. Wiring

a. General

A complete electrical firing circuit consists of the primer(s), the length of wire necessary to permit firing from a secure position, and a source of electrical current.

All wire-to-wire connections are made with splices. These must be properly made and well insulated from each other and the ground, if misfires are to be avoided. Before the charge is fired, a qualified person should check the position of the charge and the condition of the splices.

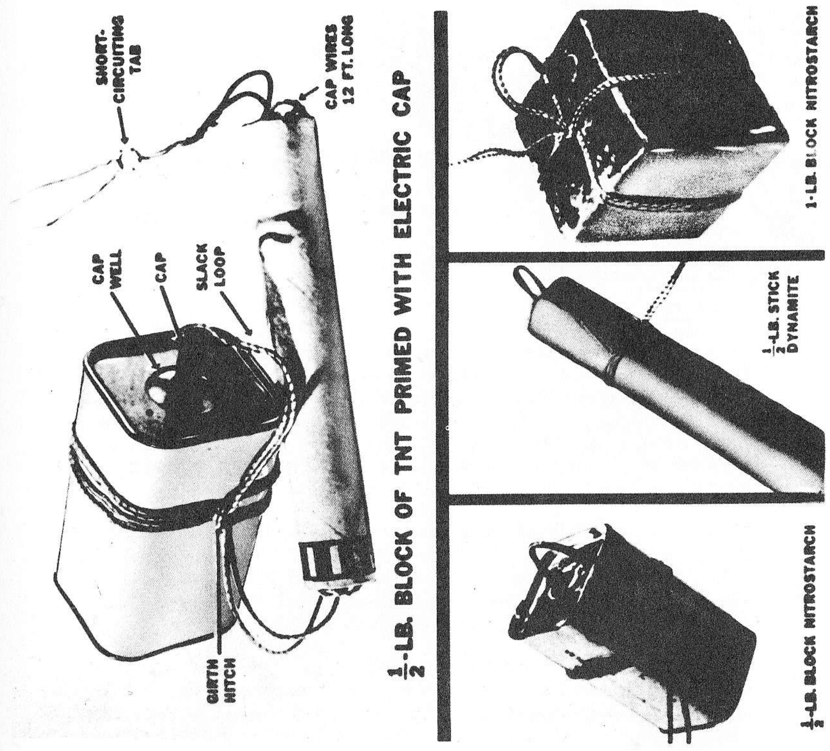


Figure 56

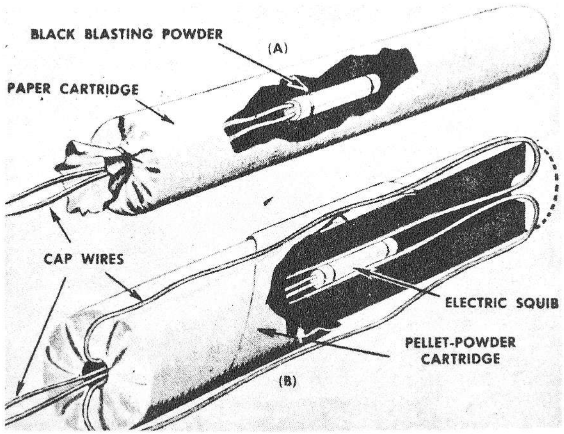


Figure 57

Black Powder Primed Electrically

b. Splicing

If wires are insulated, strip about 3 inches of insulation from the wire ends. If there is an enamel coating, remove it by scraping the wires with a knife blade, being careful not to nick them. Corrosion should be removed by scraping the wires with a dull blade or by drawing them through sand held between thumb and forefinger. The ends of stranded wire should be twisted to form a single conductor.

Fig. 58 shows a method for splicing two prepared wire ends. The wires are joined by several tight twists. The resulting tails are bent to one side and twisted to form a pigtail which is then positioned to parallel the joined wires. If necessary the joint may be insulated with tape.

When one pair of conductors is joined to a second pair, as when lengths of jumper wire are connected to firing wire, the splices should be staggered and fixed in place (see Fig. 59). This will minimize the possibility of short circuits.

Uninsulated splices should not be laid on moist ground. Sticks, stones, or even the cap's cardboard shipping sleeve may be used to fashion a simple stand which will keep the bared splice off the ground. Splices that are to be used underwater should be well sealed with friction tape. Although

these steps may appear unnecessary due to the relative conductivity of copper versus water, soil, etc., it must be remembered that electricity behaves erratically when conditions are not exactly right. Consistent success is assured only when recommended techniques are employed.

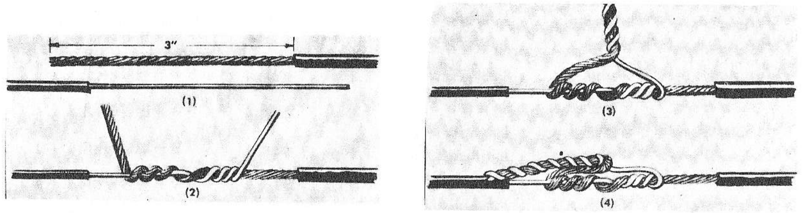


Figure 58

Method of Splicing Wires

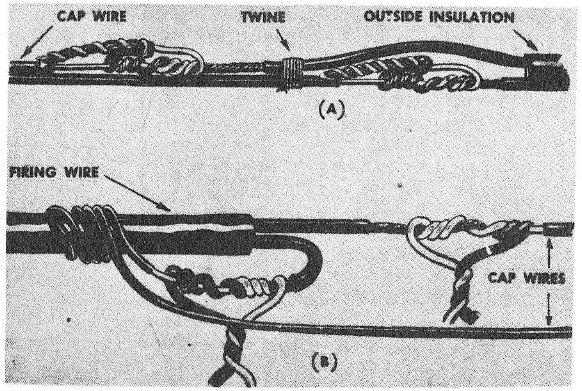


Figure 59. Method of Staggering Splices

c. Circuits

There are three circuits which are used for interconnecting blasting caps to firing wire and power source: series circuit, parallel circuit, and parallel-series circuit. For sabotage operations, the series circuit is, from the standpoint of practicality and necessity, ordinarily the only suitable one. The others require more time for placing and testing, and with certain minor exceptions require more electric power than is available from the portable type of blasting machine.

(1) Series Circuits

This circuit provides a single current path from one terminal of the power source through one strand of the firing wire to the cap(s) and back through the other strand of the firing wire to the opposite terminal of the power source. When several caps are involved, one wire of the first cap is spliced to one wire of the second cap, the remaining wire of the second cap is spliced to one wire of the third cap, and so on. After all caps have been interconnected, the free wires of the first and last caps are attached to the firing wires.

CAUTION: Accidents have occurred where extraneous currents were picked up by open lengths of cap, jumper, or firing wire. To short out stray currents, the wires should be shunted or twisted together at open ends and kept that way except when they are spliced or are connected to a blasting machine.

Series circuits are most often laid out in a simple ring pattern, as is shown in Fig. 60. A variation of this is the "leapfrog" pattern, which is nothing more than a straight-line arrangement of the ring (see Fig. 61). Notice that both of the free cap wires are at one end of the line.

(2) Parallel and Parallel-Series Circuits (See Fig. 62)

Parallel and parallel-series circuit arrangements are popular in industrial blasting, where hundreds of caps must sometimes be detonated simultaneously. In addition to requiring heavy generating equipment for power requirements, these circuits involve application of a variety of involved electrical principles. Unless these circuits are employed under the supervision of an expert blaster, the demolition project is likely to result in partial or total failure.

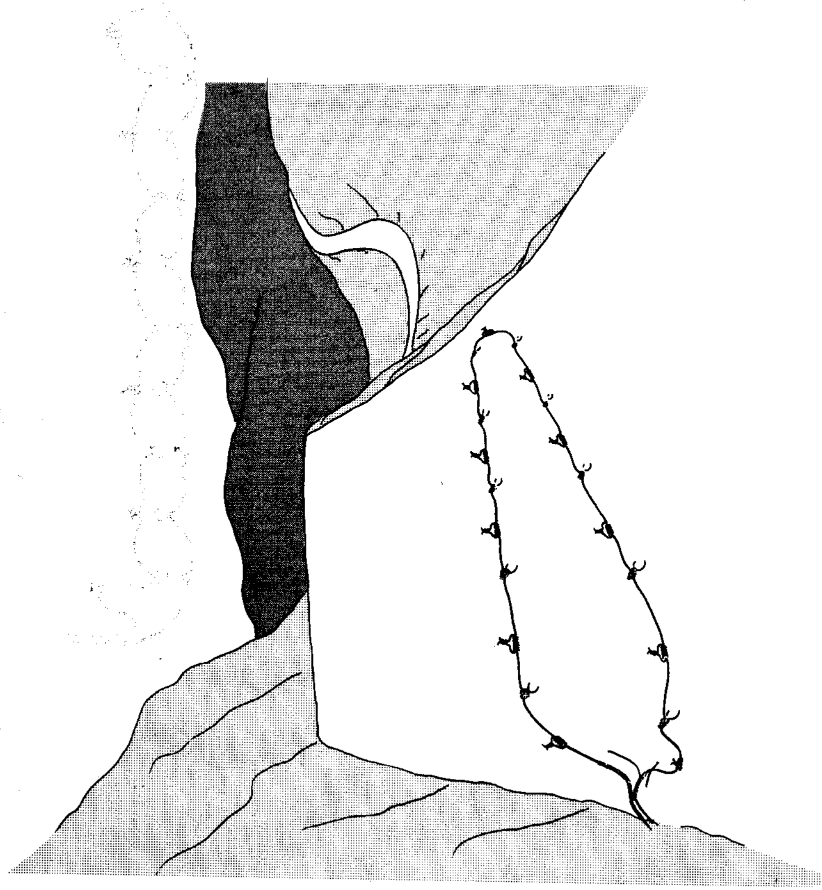
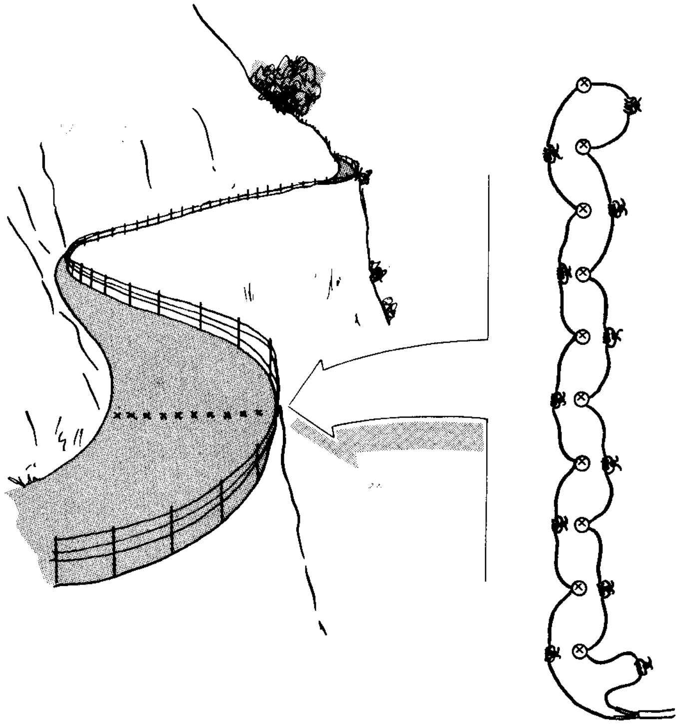


Figure 60. Ring Series Circuit



LEAPFROG SERIES CIRCUIT

Figure 61. Leapfrog Series Circuit

d. <u>Testing</u>

(1) Testing Circuits

Wiring mistakes and short circuits are not detectable with the galvanometer; they must be located by visual examination before instrument testing begins.

(2) Testing Firing Wire

Although firing wire may be tested while coiled or when wound on a reel, such a test must be considered invalid in that a wire break may hang together by the weight or pressure of adjacent coils. The wire must be laid out if a valid wire test is to be made.

(a) Separate the wires at each end of the firing wire. Touch the two wires of one end to the galvanometer posts. There should be no indication (needle movement or flash) of a complete circuit. An indication means that a short circuit exists.

(b) Twist the wires at one end together and touch the wires at the opposite end to the posts of the galvanometer. The galvanometer needle should move; if it does not there is a break in the wire.

(3) Testing Series Circuits (See Fig. 63)

After all charges are spliced in, the reel ends of the firing wire should be touched to the galvanometer posts. If the galvanometer needle moves, the circuit is complete; if not there is an open end, or some other trouble exists in the circuit, and it then becomes necessary to:

(a) Leave the reel ends of the firing wire open

(b) Proceed to the opposite end of the firing wire and touch "C" and "D" (cap wire-firing wire splices) to the galvanometer posts. If the needle moves it means there is a dirty or poor cap wire-firing wire splice or a break in the firing wire. If the needle does not move it means that the trouble is somewhere in the cap circuit; if that is the case, then:

(c) Attach to the "L" post of the galvanometer a single conductor wire ("N") long enough to reach the farthest splice in the circuit. Attach the far end of this jumper wire to "D" (cap wire-firing wire splice).

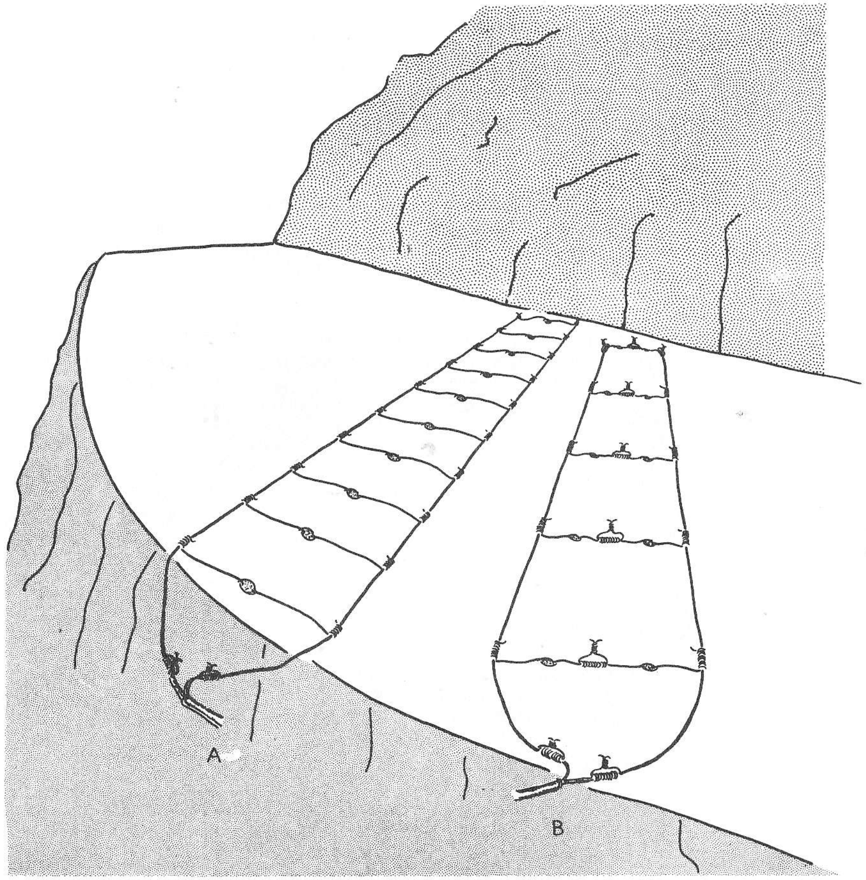


Figure 62. (A) Parallel Circuit (B) Parallel-Series Circuit

(d) Proceed to splice "O" and touch it to the vacant galvanometer post. An indication means the "O" - "D" portion of the circuit is clear. Continue around the circuit, touching each splice to the galvanometer post. When the galvanometer finally indicates no circuit, the break or other trouble exists in the portion of the circuit just bridged.

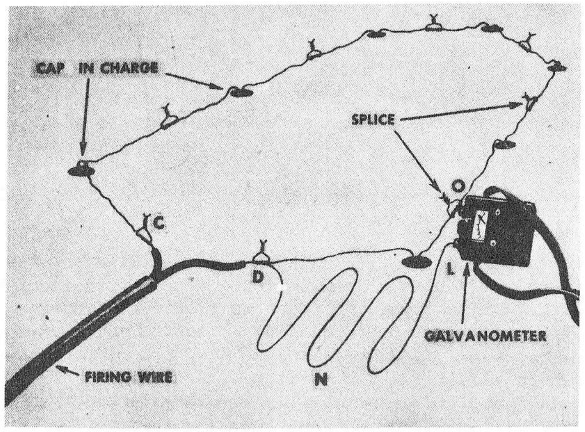


Figure 63

Testing Cap Circuits

(4) Testing Parallel and Parallel-Series Circuits

Each element of these circuits must be tested separately. This can be done by bridging each series element with the type of jumper wire described in the testing of series circuits.

e. Blasting Machine Connections

The firing wire should never be connected to a blasting machine until after the circuit has been tested and the firer is assured that everyone is out of the blast zone. After the knurled terminal taps have been loosened, the bared ends of the firing wire are turned around the terminals in the direction of the tightening thread. The knurled taps are then tightened.

Remember that blasting machines are rated according to the number of caps they will consistently fire in series through a reasonable length of wire.

4. Power Calculations (Application of Ohm's Law)

The following discussions are included to indicate the power requirements for different circuits involving varying numbers of blasting caps.

The following rules must be observed:

Use only one type and make of cap in a circuit.

Use no more than 30 caps in each series of a parallel-series circuit.

When series circuits are arranged in parallel, place the same number of caps in each series.

Use the same type and length of wire on both sides of parallel and parallel-series circuits.

CAUTION: In parallel and parallel-series circuits, one or more branches of the circuit may not fire when the charge is exploded. Care must be exercised in locating and destroying unexploded charges.

a. Ohm's Law

To calculate the number of caps which can be fired by a given power source, the basic law of electricity, Ohm's law, must be understood. The law states that the current (in amperes) supplied to any electrical circuit is equal to the potential of the electromotive force (EMF) (in volts) of the power supply, divided by the resistance (in ohms) of the circuit. This is expressed by the formula

$$I = \frac{E}{R}$$

A variation of this formula which might be used is

$$E = RI$$

I = Amperage

E = Voltage (EMF)

R = Resistance of Circuit

This law controls the layout of the wiring circuit for firing any charge electrically. Applying Ohm's law and knowing the amount of current necessary to ensure practically

instantaneous detonation of an electric blasting cap, it is possible to lay out the wiring system so that all caps are detonated.

Below are given sample calculations for determining the amperage and voltage required to fire series, parallel, and parallel-series circuits. Use of the parallel or parallel-series circuit is recommended for all charges with which more than 50 caps are used.

b. Calculation of Power Requirements for a Series Circuit

To fire a series circuit (see Fig. 60) 1.5 amperes are required, regardless of the number of caps. However, the voltage requirement increases in proportion to the number of caps used and the length of the firing wire.

Example:

Assume a circuit containing 10 Special electric blasting caps, each of which has a resistance of 2.0 ohms (see Chart 4), and 1,000 feet of standard, two-conductor, 18-gauge firing wire, which has a resistance of 6.4 ohms per 1,000 feet (see Chart 4). The total resistance of the circuit is the sum of the resistance of the caps (10 x 2.0 ohms or 20 ohms) and of the firing wire (two strands, each 1,000 feet long, or 12.8 ohms), which is 32.8. The voltage needed to force 1.5 amperes through the circuit is calculated as follows:

$$E = RI$$

Voltage = 32.8 (ohms) x 1.5 (amperes)

Voltage = 49.2 (or 50)

The circuit can be fired with 1.5 amperes and 50 volts.

c. Calculation of Power Requirements for a Parallel Circuit

In a parallel circuit (see Fig. 62 A) less current (0.6 amperes) is required to fire each individual cap, but the total amperage increases proportionately with the number of caps. Thus 10 Special blasting caps would require 0.6 amperes x 10 or 6 amperes (see Chart 4).

Chart 4. Data for Use in Electric Firing System Calculations

1. Current needed to fire electric caps connected in series	= 1.5 amperes
2. Current needed to fire electric caps connected in parallel	= 0.6 amperes x number of caps in circuit
3. Resistance of one Special electric cap	= 2.0 ohms
4. Total resistance of caps connected in series	= 2.0 ohms x number of caps
5. Total resistance of caps connected in parallel	= 2.0 ohms ÷ number of caps
6. Resistances of copper wire of various gauges:	

Gauge No. A.W.G.	Use	Diameter (in inches)	Length-Weight Relationship (in ft. per lb.)	Resistance (in ohms per 1,000 ft.)
2	Heavy-Duty Powerlines	$\frac{3}{10}$	5.0	0.2
4	"	$\frac{1}{4}$	7.9	0.3
6	"	$\frac{1}{6}$	12.6	0.4
8	Power-lighting Circuit Lines	$\frac{1}{8}$	20.0	0.6
10	"	$\frac{1}{10}$	31.8	1.0
12	"	$\frac{1}{12}$	50	1.6
14	Common Lead Lines	$\frac{1}{16}$	80	2.5
16	"	$\frac{1}{20}$	128	4.0
18	Common Lead Lines; Standard Two-conductor Firing Reel	$\frac{1}{25}$	203	6.4
20	Common Connecting Wire	$\frac{1}{30}$	323	10.2

(1) Resistance of Wire

In a parallel circuit, the resistance of the wire is that of the average path which the current follows in reaching all caps. For practical purposes this may be calculated as follows:

(a) Determine the resistance from the power source to the nearest cap and back to the power source.

(b) Determine the resistance of the wires connecting the nearest and farthest cap and divide by two.

(c) Add (a) and (b), above, to obtain the total wire resistance.

(2) Resistance of Caps

The total resistance of the caps in the circuit decreases proportionately as the number of caps in the circuit increases, since the current must pass through several cap wires. Thus, 10 Special caps connected in parallel would have a resistance of 2.0 ohms per cap divided by 10, or 0.2 ohms (see Chart 4).

Example:

Assume a circuit containing 10 caps connected in parallel with 20-gauge wire (having a resistance of 10.2 ohms per 1,000 feet) at 20-foot intervals and joined to the power source by 500 feet of standard, two-conductor firing wire (having a resistance of 6.4 ohms per 1,000 feet). The voltage required to force 6 amperes through the circuit is calculated as follows:

$$E = RI$$

$$\text{Voltage} = \text{Ohms} \times \text{Amperes}$$

The resistance of the wiring (excluding that of the caps) is that of the firing wire (1,000 feet at 6.4 ohms per 1,000 feet) and two 20-foot strands of 20-gauge wire (40 feet at 10.2 ohms per 1,000 feet)

$$1{,}000 \times \frac{6.4}{1{,}000} + 40 \times \frac{10.2}{1{,}000} = 6.4 + .4 = 6.8 \text{ ohms}$$

Plus that of eighteen 20-foot strands of 20-gauge wire divided by 2

$$18 \times 20 = 360$$

$$\frac{360 \times \frac{10.2}{1{,}000}}{2} = 1.8 \text{ ohms.}$$

The total wire resistance is therefore 6.8 ohms + 1.8 ohms, or 8.6 ohms.

The total resistance of the circuit is the sum of the average wire resistance, 8.6 ohms, and the cap resistance, 0.2 ohms, or 8.8 ohms. Substituting in the formula

$$E = RI$$
$$\text{Voltage} = 8.8 \text{ (ohms)} \times 6 \text{ (amperes)}$$
$$\text{Voltage} = 52.8 \text{ (or 53)}$$

The circuit can be fired with 6 amperes and 53 volts.

d. Calculation of Power Requirements for a Parallel-Series Circuit

A parallel-series circuit is made up by connecting several series of caps in parallel (see Fig. 62 B). In this type of circuit, 1.5 amperes are required for each series regardless of the number of caps in the series. Therefore, total amperage required is 1.5 times the number of series.

(1) Resistance of Wire

Wire resistance is calculated as for a parallel circuit.

(2) Resistance of Caps

The resistance of the caps is calculated on a basis of 2 ohms per cap in any one series, divided by the number of series in the circuit. Thus, a circuit with 5 series of 10 caps each has a total cap resistance of 2 ohms x 10 (20 ohms) divided by 5, or 4 ohms.

Example:

Assume a circuit of 5 series of 2 caps each connected in parallel with 20-gauge wire (10.2 ohms resistance per 1,000 feet) at 40-foot intervals and joined to the power source by 500 feet of standard, two-conductor firing wire. The amperage and voltage requirements are calculated as follows:

Amperes = 1.5 (amperes per series) x 5 (number of series) = 7.5

Each series has a resistance of 2.0 ohms x 2, or 4 ohms. As there are 5 series in parallel, the combined cap resistance is 4 ÷ 5 or .8 ohms.

The wire resistance is that of the 500 feet of firing wire, 80 feet of connecting wire (20-gauge), (6.4 + .8 = 7.2 ohms), and eight 40-foot strands of connecting wire (20-gauge), divided by 2

$$8 \times 40 = 320$$

$$\frac{320 \times \frac{10.2}{1{,}000}}{2} = 1.6 \text{ ohms}$$

Thus, 7.2 + 1.6 = 8.8 ohms.

The total resistance of the circuit is the sum of the resistances, .8 ohms + 8.8 ohms, or 9.6 ohms.

The minimum voltage required to fire the circuit is determined as follows:

$$E = RI$$
$$\text{Voltage} = \text{ohms} \times \text{amperes}$$
$$\text{Voltage} = 7.5 \times 9.6$$
$$\text{Voltage} = 72$$

The circuit can be fired with 7.5 amperes and 72 volts.

From these discussions and examples, it is apparent that the 10-cap blasting machine, which is rated at $1\frac{1}{2}$ amperes, cannot deliver sufficient current for even small parallel and parallel-series circuits.

e. Capacity of Power Plants

The name-plate amperage and voltage rating of a power plant or a generator can be used to determine the maximum number of series that can be placed in a parallel-series circuit and also to determine the maximum number of caps per series. To calculate the capacity of a generator, proceed as follows:

(1) Divide the amperage of the generator by 1.5 to get the number of series that can be connected in parallel.

(2) Divide the voltage of the generator by the total amperage of the circuit (1.5 x number of series) to determine the maximum resistance in ohms that can exist in the circuit.

(3) Subtract the firing-reel and connecting-wire resistance from the maximum allowable resistance (calculated in (2), above). The remainder is the allowable resistance of the caps in the circuit.

(4) To calculate the maximum number of caps per series, multiply the allowable resistance of the caps in the circuit by the number of series and divide by the resistance of one cap (2.0 ohms).

Example:

Assume a firing system has (1) a 3-kw, 220-volt, 13.5-ampere generator; (2) a proposed circuit containing Special blasting caps; (3) a 500-foot, two-conductor, standard firing wire; and (4) 200 feet of 20-gauge connecting wire. The maximum number of caps per series and the number of series is calculated as follows:

$13.5 \div 1.5 = 9$ (number of series that can be connected in parallel)

$220 \div (1.5 \times 9) = 220 \div 13.5 = 16.2$ ohms (maximum allowable resistance of circuit)

The resistance of the wiring is that of the firing wire (6.4 ohms) plus half that of the connecting wire ($\frac{200}{2} \times \frac{10.2}{1{,}000}$ ohms)

(see Chart 4). If all the connecting wire is used to connect the series and the circuit is connected to the generator by the firing reel, then the total resistance of the wiring is 6.4 ohms + 1.0 ohm = 7.4 ohms.

16.2 ohms - 7.4 ohms = 8.8 ohms, or the maximum allowable resistance of the caps in the circuit.

Maximum Number of Caps per Series $= \frac{9 \times 8.8}{2.0} = \frac{79.2}{2.0} = 39.6$

5. Electric Dual Firing System

The electric dual firing system consists of two independent electric firing circuits. Each charge must contain two electric primers. Fig. 64 shows the correct method of laying out an electric dual firing system. This is practical only when unlimited placing time is available, as in training or denial programs.

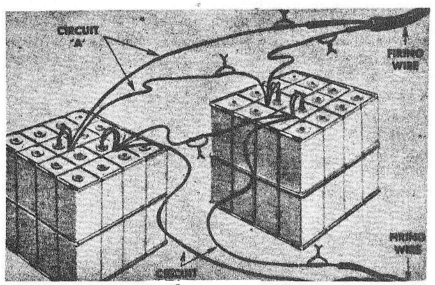


Figure 64

Electric Dual Firing System

6. Combination (Electric and Non-Electric) Dual Firing System

The combination dual firing system provides an electric and a non-electric means of firing charges. Each charge contains both an electric primer and a nonelectric primer, made either with a cap or detonating cord. For multiple charges to be fired simultaneously, the nonelectric primers must be made with detonating cord. Fig. 65 shows the correct method of laying out combination dual firing systems. Operationally, the simple nonelectric system should be completed before the electric circuit, thus providing

a means for firing if some emergency occurs to prevent completion of the project.

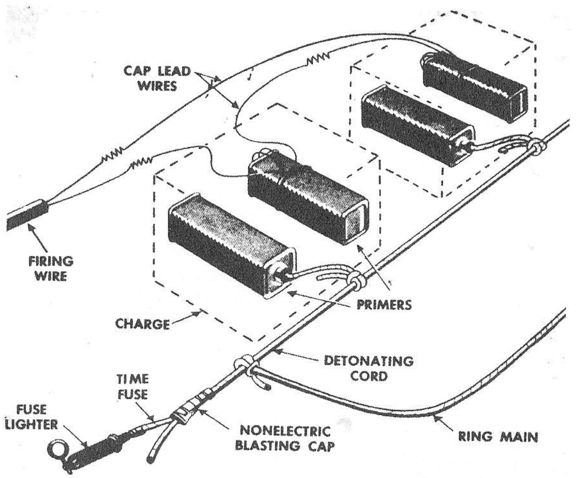


Figure 65. Combination Dual Firing System

7. Improvised Electric Equipment

a. Wire

Many types of electric and telecommunication wire may be adapted to firing-circuit use. Wire which has an extremely small diameter has a high resistance, while large-diameter wire is heavy and therefore is difficult to transport. Before "scavenged" wire is used operationally, it should be tested in some remote area in a circuit which duplicates the operational circuit.

b. Power

(1) Storage Battery

The average automobile storage battery is rated at 6 volts and is capable of putting out over 300 amperes for short periods of time. This may be substituted for a blasting machine. In view of the limited voltage, parallel circuits should be used (instead of series and

parallel-series circuits) and firing wire should be of a larger diameter than No. 18 A. W. G. (see Chart 4).

(2) Flashlight Batteries

A single, flashlight-type dry cell is rated at 1.5 volts and is capable of putting out over 6 amperes for short periods of time. A single flashlight cell will initiate only one Special blasting cap. This does not include additional firing wire, so the practical use of a single cell is somewhat limited.

Cells and batteries may be connected in series to increase the voltage, or in parallel to increase the amperage. When voltage is increased amperage remains the same, and vice versa (see Fig. 66). By various series and parallel arrangements of cells, it is theoretically possible to meet the power requirements of any circuit.

(3) Radio Generators

Many types of small, portable, hand-operated, radio-type generators may be adapted for use in electrical firing circuits.

(4) House Current

Although direct current is more suitable for electric blasting circuits, alternating current may be used. Generally speaking, a voltage of 220 is preferable to either higher or lower values and a 60-cycle frequency is more desirable than a 25-cycle frequency.

c. Expedient Wire Tests

To determine whether long lengths of "scavenged" wire are open or short-circuited, the tests outlined in Subsection C. 3. of this Section may be applied. A source of power such as a storage battery may be used instead of a galvanometer. One wire should be fastened to one terminal of the battery and the other (held at the insulated part) stroked against the opposite terminal. Sparking indicates a short circuit, if opposite ends are apart, or a complete circuit if the wires at the opposite end are closed. If no spark is visible, the cause may be weak current flow. In such a case a field compass, metal knife, or screwdriver may be used to indicate whether or not a circuit exists. The free wire is wrapped

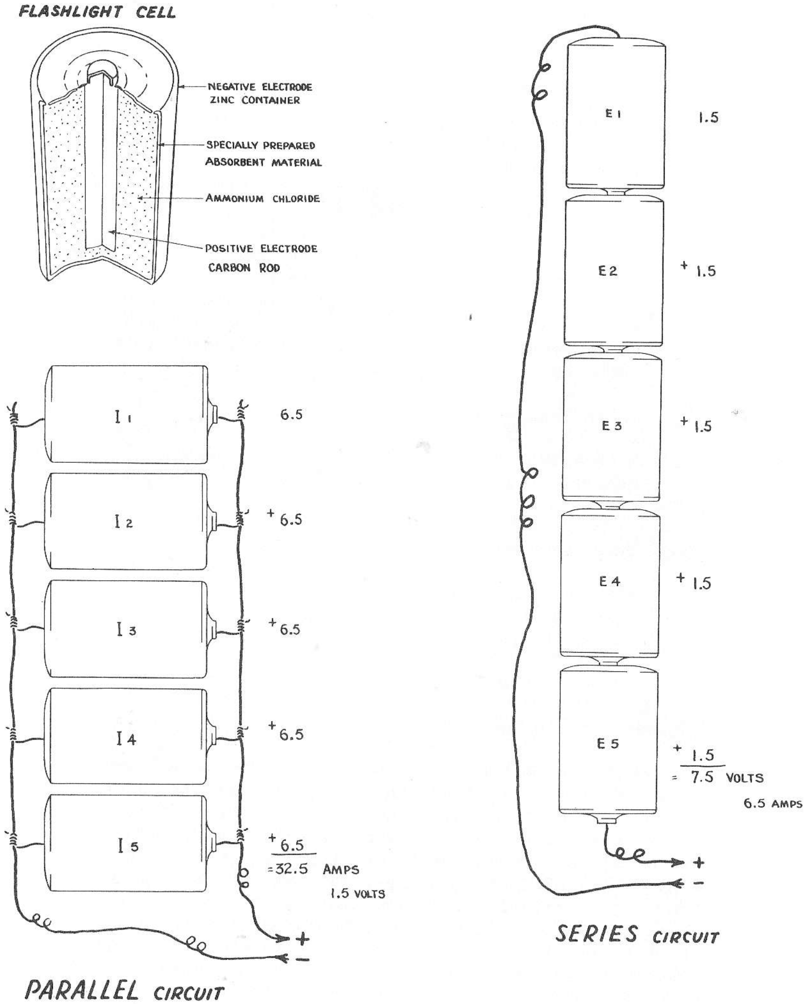


Figure 66. Method of Connecting Flashlight Drycells To Change Voltage or Amperage Characteristics

about the compass, knife, or screwdriver (see Fig. 67). If a circuit exists, when this wire is touched to the battery terminal the magnetic flux set up by the coil will cause the compass needle to fluctuate, or, if a knife or screwdriver is used, it will become magnetized.

(Note: High-resistance wire may melt or become extremely hot when current is applied.)

CAUTION: Never attempt to test a circuit containing blasting caps with power derived from the improvised sources described above. Only the special, silver-chloride test cell found in the one type of galvanometer is suitable for testing cap circuits.

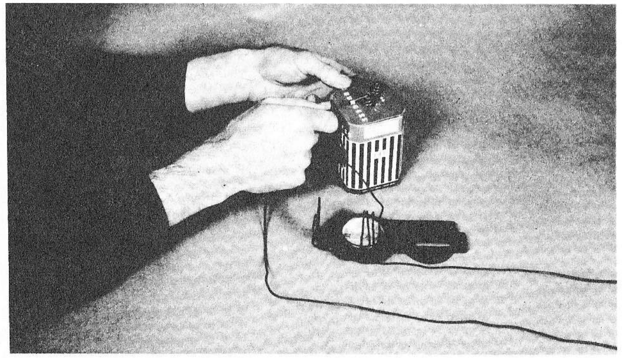


Figure 67. A

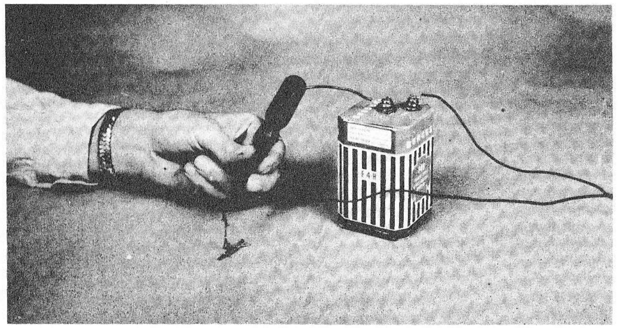


Figure 67. B

SECTION 8. CALCULATION AND PLACEMENT OF CHARGES

A. General

The effect that an explosion will produce on an object is governed by such things as the kind and quantity of the explosive used, the relative positions of explosive and object at the time of the explosion, the physical characteristics of the object, and the type and quantity of medium in which the explosion occurs.

The experienced explosives man knows at a glance how to place a proper quantity of a particular explosive so that a desired effect is produced upon a given object. Such a skill comes only to those few "blasters" who have had long experience in general blasting and demolitions. In order that inexperienced personnel be capable of achieving a reasonable degree of success, the formulas and rules governing the calculation and placement of explosive charges are outlined below. The formulas and rules must be considered as a guide, to be modified as necessary for each project, based on existing conditions and, more important, on test shots or previous experience under similar conditions.

It may be assumed to be sufficiently exact for field purposes that charges of the same explosive develop energy in direct proportion to their weight. This energy is exerted in all directions simultaneously and has a compressive effect on the surrounding medium, be it air, earth, water, timber, concrete, or steel. Therefore, an explosive which is sealed tightly inside an object to be destroyed exerts force on the material all around it and gives the maximum destructive effect. If the material surrounding an explosive is not equally strong on all sides, the force breaks through the weakest point. Where explosions occur in mixed media as when a charge is placed on the ground against a target concrete pier, the expanding explosive forces are resisted more by the concrete and earth than by the air. Consequently, a marked distortion of the expanding sphere occurs as the forces vent in the direction of least resistance. Only a small part of the explosive's total energy affects the concrete. If a sufficient quantity of explosive is used, the part of the concrete pier in contact with the explosive will appear to shatter instantaneously. If insufficient explosive is used, the explosion may remove only part of the target.

By placing an overburden of material more dense than air over and around an explosive charge, more of an expanding explosive force is directed against the target. This overburden is referred to as tamping material. In some cases, proper confinement or tamping may reduce an explosive requirement by as much as 75 percent.

In sabotage, where materials are extremely limited, it is important that explosives be wisely used. This would appear to make tamping material a requirement for operations; however, since the time and trouble necessary to tamp a charge properly are considerable, tamping may be impossible in many cases.

B. Cutting Steel and Cast Iron

1. Steel

To the layman, steel is a refined iron which is tenacious, elastic, and malleable. Terms such as structural steel, tool steel, spring steel, rail steel, forged steel, and cast steel are not scientific ones and are understood by everyone. Chemically speaking, the steels mentioned above are radically different; however, since the differences between them are not ordinarily apparent upon cursory examination, it is necessary to regard most steels as possessing the characteristics of a high-grade alloy steel, a steel tougher than that ordinarily found in mass-produced steel products.

The following formulas may be used to determine the size of an untamped TNT charge needed to cut steel objects:

a. Structural Steel (See Fig. 68)

To cut structural steel, use the following formulas:

$P = \frac{3}{8} A$	OR, for the metric system $K = \frac{1}{36} A$
P = Pounds of TNT required	K = Kilograms of TNT required
A = Cross sectional area in square inches	A = Cross sectional area in square centimeters

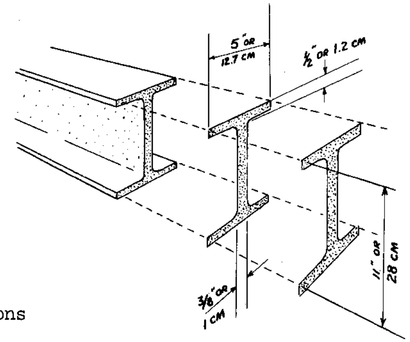


Figure 68

I Beam Dimensions

Charge Calculations
(For conversions to metric system see Chart 5)

Formula: $P = \frac{3}{8} A$	Formula: $K = \frac{1}{36} A$
Flange Area = $2 \times \frac{1}{2} \times 5 = 5$ sq. in.	Flange Area = $2 \times 1.2 \times 12.7 = 30$ sq.cm.
Web Area = $\frac{3}{8} \times 11 = 4\frac{1}{8}$ sq. in.	Web Area = $28 \times 1 = 28$ sq.cm.
A (total) = 5 sq. in. + $4\frac{1}{8}$ sq. in. = $9\frac{1}{8}$ sq. in.	A (total) = 30 sq.cm. + 28 sq.cm. = 58 sq.cm.
$P = \frac{3}{8} A = \frac{3}{8} \times 9\frac{1}{8} = \frac{219}{64}$	$K = \frac{1}{36} A = \frac{1}{36} \times 58 = \frac{58}{36}$
$P = 3.42$	$K = 1.6$
Use 3.5 pounds of TNT.	Use 1.6 kilograms of TNT.

Chart 5. Conversion chart

2.54	centimeters per inch
10	centimeters per decimeter
100	centimeters per meter
3.937	inches per decimeter
1,000	grams per kilogram
453	grams per pound
2.2	pounds per kilogram

To compute the quantity of another type of explosive required to defeat an object, it is first necessary to determine how much TNT would be needed. The amount of TNT is then divided by the RE (relative effectiveness) factor of the particular explosive considered for use. For example, suppose composition C-4 is to be substituted for TNT in the previous example. C-4 has a 1.30 RE factor; this is divided into the 3.5 pounds or 1.6 kilograms of TNT required.

3.5 lbs. ÷ 1.30 = 2.7 lbs.	1.6 kg. ÷ 1.30 = 1.2 kg.
Use 2.7 pounds of C-4.	Use 1.2 kilograms of C-4.

b. Cross Sectional Rounds (See Fig. 69)

To determine the quantity of TNT necessary to cut reinforcing bars, cables, chains, etc. whose shape makes good contact between steel and explosive impossible, the following formulas are used:

$P = A$	OR, for the metric system $K = \frac{1}{14} A$
P = Pounds of TNT required	K = Kilograms of TNT required
A = Cross sectional area in square inches	A = Cross sectional area in square centimeters

The cross sectional area of a round object is equal to pi (3.14) times the radius squared. This is normally expressed as: $A = \Pi R^2$

Charge Calculations

$A = \pi R^2$	$A = \pi R^2$
$A = 3.14 \times (2)^2$	$A = 3.14 \times (5)^2$
$A = 3.14 \times 4$	$A = 3.14 \times 25$
$A = 12.56$	$A = 78.50$
$P = A = 12.56$ lbs.	$K = \frac{1}{14} A = \frac{1}{14} \times 79 = \frac{79}{14}$
	$K = 5.6$ kg.
Use 12.5 pounds of TNT.	Use 5.6 kilograms of TNT.

If C-4 is to be used, there is no problem of contact between the steel and the explosive, and it is therefore permissible to use the original formula, $P = \frac{3}{8} A$, divided by 1.30. The following problem refers to the previous example:

$$P = \frac{3}{8} \times 12.56 = \frac{37.7}{8} = 4.7 \text{ lbs. of TNT}$$

$$P = 4.7 \text{ lbs.} \div 1.30 = 3.6 \text{ lbs. of C-4}$$

Use 3.6 pounds of C-4.

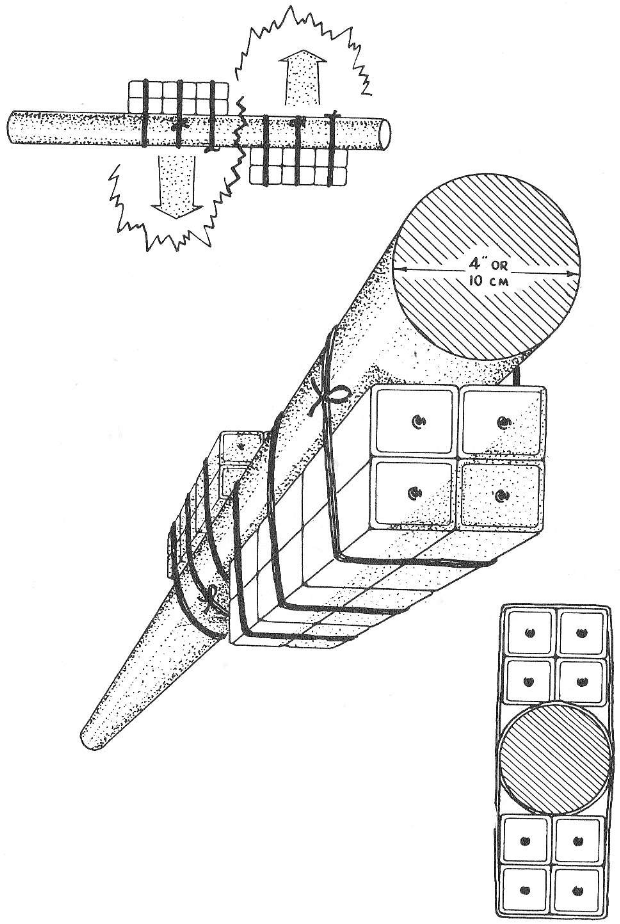


Figure 69

Cross Sectional Round Dimensions

c. Rule of Thumb (See Fig. 70)

When individuals are incapable of comprehending the steel-cutting formulas previously presented, the following general rule may be applied with a high degree of success. Mold C-3 or C-4 so that its mass is a bit higher, a bit wider, and as long as the rupture desired.

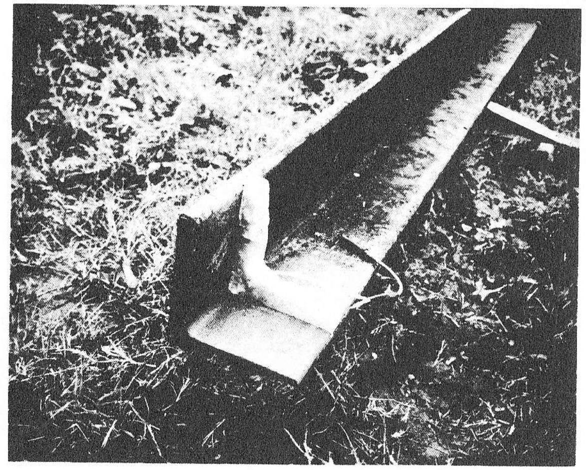


Figure 70

d. Railroad Rails

The steel used for rails has a high carbon content which makes it brittle or less elastic than other structural steels; therefore, considerably less explosive is required to defeat it.

To cut 80-pound or lighter rail, place one-half pound of TNT against the web. Heavier rails may be cut by 1 pound of TNT or by three-fourths of a pound of C-4-type explosive similarly placed.

More detailed information on rail sabotage will be given in Volume III of this Handbook in a chapter entitled, "Railroad Transportation."

2. Cast Iron

Cast iron is widely used industrially in steam cylinders, gear spiders, gear housings, bearing pedestals, and machinery bases. It may be recognized by its grainy finish, rounded corners, and by the fact that it frequently bears raised lettering. It very often is a primary sabotage target because repairs are difficult and require special equipment. In most cases, if there is even a simple crack in a piece of cast iron the piece must be replaced.

Cast iron has a relatively high carbon content which makes it very hard but so brittle that it shatters somewhat like glass when struck a heavy blow. No formula or rule exists for computing the amount of explosive necessary to defeat a given thickness of cast iron; however, because of cast iron's brittleness, the amount of explosive required will be considerably less than that required for a steel member of similar size. This should always be demonstrated by test shots during training.

3. Placing of Charge

The primary requirement in attacking metals, or any other material, successfully with a minimum of explosive is to have intimate contact between explosive and target. Air gaps, even small ones, permit a dissipation of expanding gases, thus detracting from the possible effect. Built-up girders with corner-angle bracing make it difficult to obtain close contact between steel and cast-types of explosives. Plastic explosives serve perfectly in such situations, for the mass may be molded to conform to the shape of all irregular surfaces.

To divide a steel object of uniform thickness, the explosive mass should approximate a cross sectional square and extend along the desired line of rupture. Flanged or built-up members require heavier concentrations of explosive at the corners and at other points where the steel object is unusually thick. If a steel member is of such size as to require the distribution of explosive on opposite sides of it, the opposing portions of the charge should be slightly offset in order to produce a shearing or scissoring action (see Figure 71). If the opposing portions are placed directly opposite one another each tends to neutralize the other, and a reduced effect is apparent. Rods, bars, and cables tend to bend and stretch if a blow is struck on only one side; for this reason, the calculated charge should be divided into two equal portions and placed to produce shearing action.

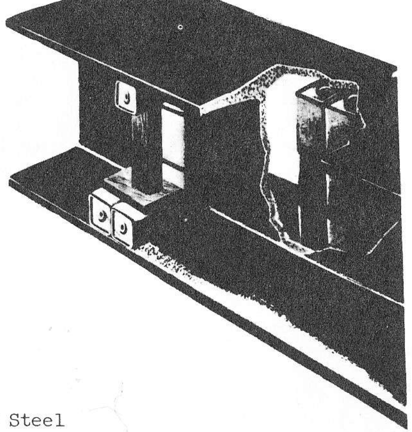


Figure 71

Offset Placing to Shear Steel

Fig. 72 shows how explosive charges should be placed on various types of structural shapes and built-up girders. Notice that the smaller charges are of the standard type. These are quite versatile in that they may be used as is, may be divided so as to reach the stress points of a particular member (this is done by cutting through the wrapper and explosive and leaving the detonating cord intact), or may be cut in half.

As indicated in Fig. 72, all charges should be firmly secured to target objects. This is especially necessary where a charge is attached to an object that is subjected to vibration. Securing is most often accomplished with tape or rope. Several types of quick tying arrangements may be improvised from knotted rope, heavy rubber bands, or notched boards. Also, there are issue and commercial types of adhesive compounds which are suitable for fixing light charges to target objects. Magnets are particularly ideal for fixing charges to iron objects, but their expense and restricted availability prevent wide usage.

Steel-cutting explosive charges hurl fragments of steel long distances at high velocities. If explosives in contact with frangible materials are to be detonated while friendly forces are in the blast vicinity, the charges should be placed so that debris is hurled in directions away from such personnel (see Fig. 73). This will minimize the flight of debris in certain directions, but personnel must still take cover from both flat-trajectory and high-angle fragments.

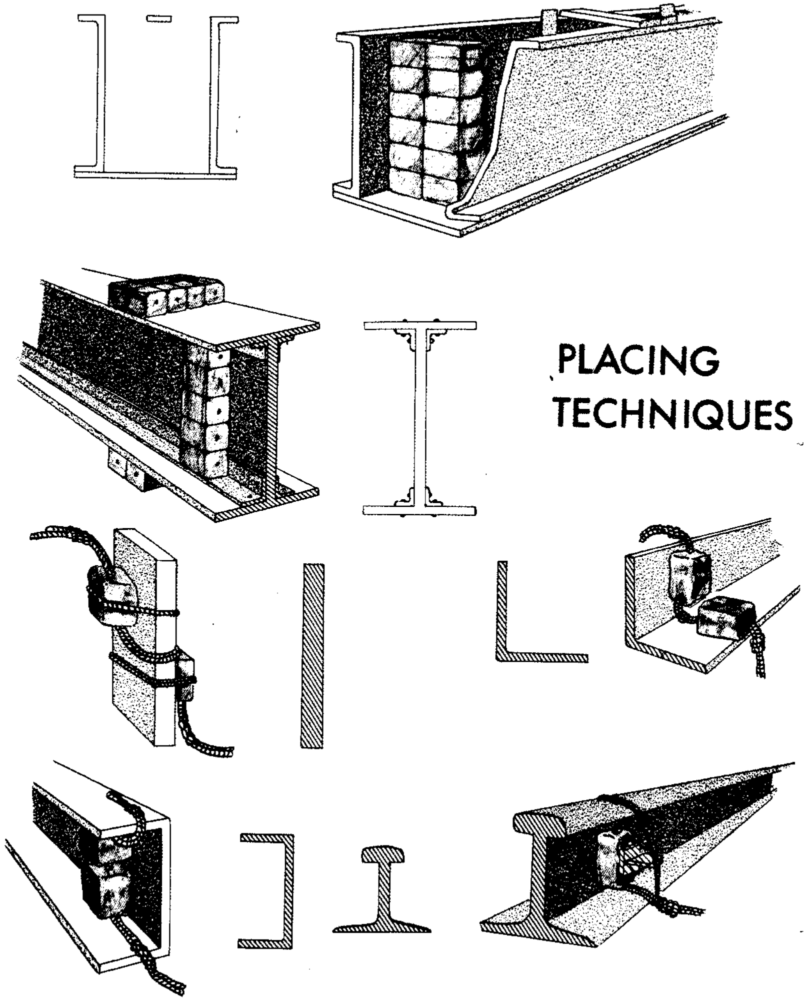


Figure 72

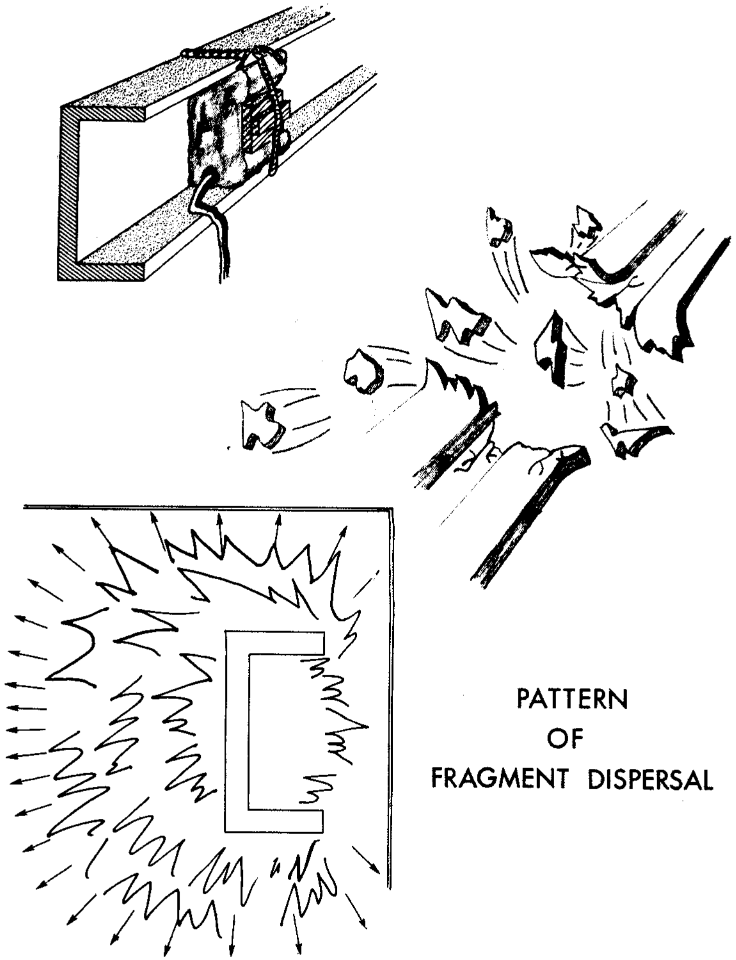


Figure 73

When machinery (electric motors, generators, turbines, machine tools, etc.) is attacked with explosives, the charges should be placed on the undersides of critical parts whenever possible. The lifting shock associated with such placement may destroy or damage the foundation or alignment of the machine. This is incidental to the destruction of the critical machine part, but should be taken advantage of when possible.

C. Cutting Timber

1. General

Timber can be destroyed by fire and by cutting as well as by explosives. Explosives are used when the demolition must be delayed until a given moment and then carried out at once. Although internally placed charges effect a great saving in explosives, the considerable time required for boring and loading holes will generally prohibit use of this technique.

2. Calculation of Charges

a. Formulas for External Placement of Charge

(1) Charges for cutting trees, timber piles, posts, etc. should be calculated by means of the following formulas:

$P = \frac{D^2}{40}$	OR, for the metric system	$K = \frac{D^2}{550}$
P = Pounds of TNT required		K = Kilograms of TNT required
D = Diameter of target in inches		D = Diameter of target in centimeters
	(See Fig. 74) Charge Calculations	
$P = \frac{D^2}{40}$		$K = \frac{D^2}{550}$
$P = \frac{12^2}{40} = \frac{144}{40}$		$K = \frac{30^2}{550} = \frac{900}{550}$
P = 3.6 lbs.		K = 1.64 kg.
Use 4 pounds of TNT.		Use 1.6 kilograms of TNT.

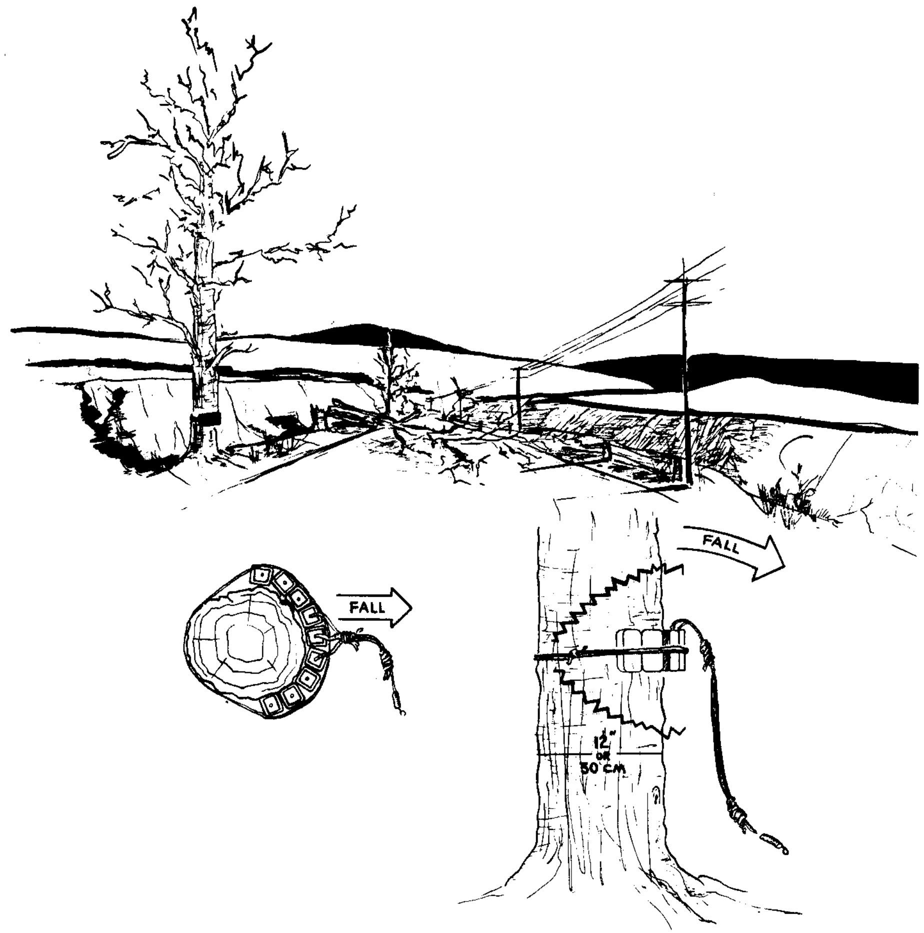


Figure 74

Placement of Charges on Timber Rounds

(2) To cut timber with square or rectangular cross sectional areas, the following formulas should be used:

$P = \frac{A}{40}$ OR, for the metric system $K = \frac{A}{550}$

P = Pounds of TNT required	K = Kilograms of TNT required
A = Cross sectional area in square inches	A = Cross sectional area in square centimeters

(See Fig. 75)

Charge Calculations

$P = \frac{A}{40}$	$K = \frac{A}{550}$
$P = \frac{10 \times 12}{40} = \frac{120}{40}$	$K = \frac{25 \times 30}{550} = \frac{750}{550}$
P = 3 lbs.	K = 1.36 kg.
Use 3 pounds of TNT.	Use 1.36 kilograms of TNT.

b. Formulas for Internal Placement of Charge

(1) Formulas for calculation of internally placed charges are:

$P = \frac{D^2}{250}$ OR, for the metric system $K = \frac{D^2}{3500}$

P = Pounds of TNT required	K = Kilograms of TNT required
D = Diameter of target in inches	D = Diameter of target in centimeters

(See Fig. 74)

Charge Calculations

$P = \frac{D^2}{250}$	$K = \frac{D^2}{3500}$
$P = \frac{12^2}{250} = \frac{144}{250}$	$K = \frac{30^2}{3500} = \frac{900}{3500}$
P = .57 lbs.	K = .257 kg.
Use .6 pounds of TNT.	Use 260 grams of TNT.

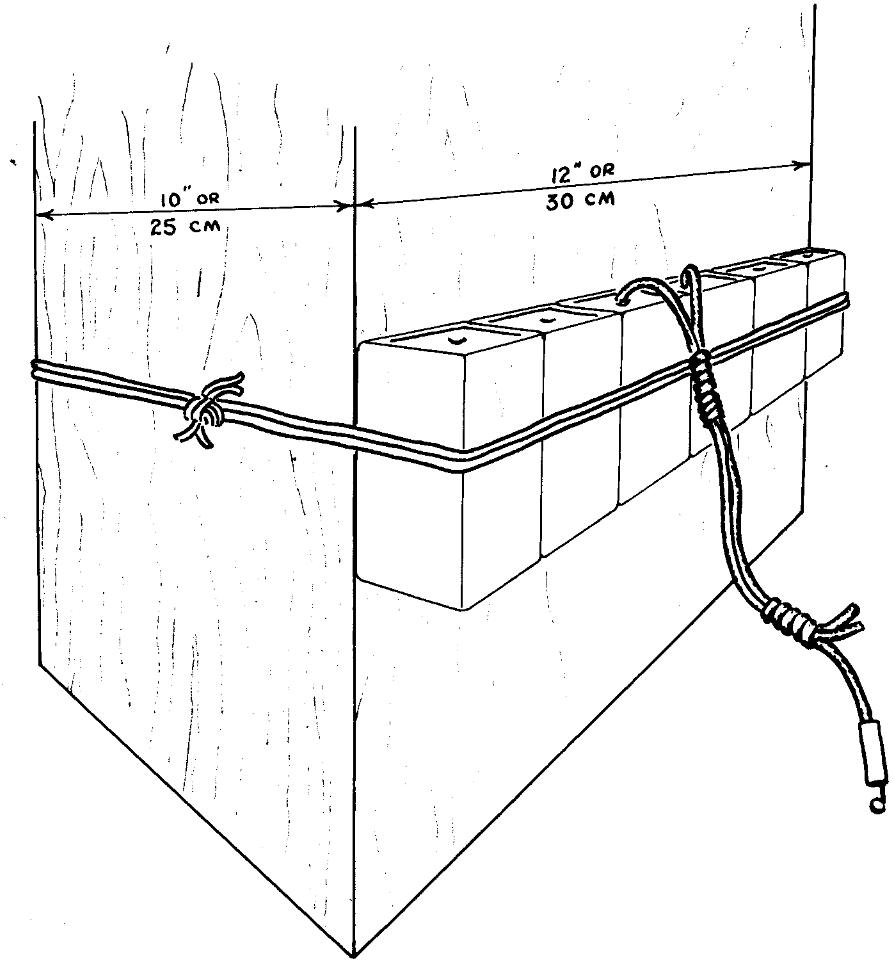


Figure 75

Placement of Charges on Cut Timber

(2) Timbers with square or rectangular cross sectional areas may be cut with charges calculated by means of the following formulas:

$P = \frac{A}{250}$	OR, for the metric system $K = \frac{A}{3500}$
P = Pounds of TNT required	K = Kilograms of TNT required
A = Cross sectional area in square inches	A = Cross sectional area in square centimeters

3. Placement of Timber Charges

It is advantageous to place TNT blocks with their longitudinal axes perpendicular to the plane of the section to be cut, as is shown in Fig. 74. The charge should not extend more than halfway around the object to be cut. In the case of rectangular timber not having a square cross section, the charge should be distributed on one of the longer faces. To cut timber piling underwater, pole charges similar to those shown in Fig. 76 may be used. In cases where 2 to 3 feet of water tamping exist and where intimate contact of explosive with timber is assured, the size of a calculated charge may often be halved.

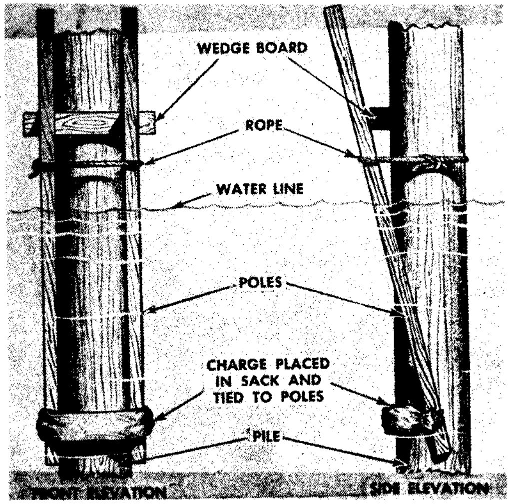


Figure 76

Placement of Underwater Timber Charges

Timber boreholes should at least penetrate the core of the object and be of a diameter large enough to hold the calculated amount of explosive.

Cast explosives must be pulverized before they can be loaded (see Fig. 77). After priming, borehole charges should be tamped with moist earth or clay.

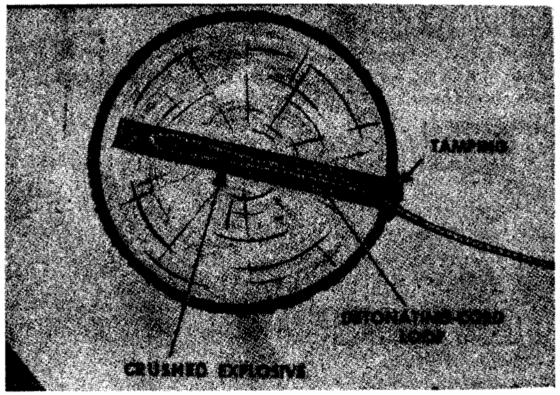


Figure 77

Internal Timber Charge

(Note: Extremely dry timber is often ignited by the extreme heat and flash of detonation. TNT is less likely to cause ignition than some other types of explosives.)

D. Breaching Charges

1. General

Structures of concrete, masonry, rock, or similar materials are generally of such size that unusually large quantities of explosives are needed for their complete destruction. Saboteurs and guerrillas normally lack the large amounts of explosive necessary to even partially damage important bridges, tunnels, etc. Also, transportation of the material and the time required for the placement of multiple charges would present major problems in resistance situations. Targets such as square bridge piers, machinery support columns, etc., are of a size more in keeping with a saboteur's capability.

2. Breaching Formulas

Breaching charges are calculated by means of the following formulas:

$P = \frac{R^3 KC}{2}$ OR, for the metric system $K' = \frac{R^3 KC}{120}$

P = Pounds of TNT required

R = Breaching radius in feet

K' = Kilograms of TNT required

R = Breaching radius in decimeters

K = The material factor (based on strength and hardness of material to be demolished)

C = The tamping factor (based on type and extent of tamping associated with a charge)

(Note: Add 10 percent to a calculated charge of less than 50 pounds or 22.5 kilograms.)

a. Breaching Radius

The breaching radius (R) is the distance in feet or decimeters which an explosive charge must penetrate and within which all material is displaced or destroyed. It is measured from the surface on which an explosive is placed. For example, if it is desired to breach a 2-foot concrete wall by placing a charge on one side, then the value R in the formula $P = \frac{R^3 KC}{2}$ is 2.

b. Material Factor

The values of the material factor (K) for various types of construction are given in the following chart:

Chart 6. Values of Material Factor (K) for Use in Calculation of Breaching Charges

Material	R	K
Ordinary earth	All values	0.10
Poor masonry, shale and hardpan, good timber-and-earth construction	All values	.45
Good masonry, ordinary concrete, rock	Less than 3 feet 3 to 5 feet 5 to 7 feet More than 7 feet	.70 .55 .50 .45
Thick concrete, first-class masonry	Less than 3 feet 3 to 5 feet 5 to 7 feet More than 7 feet	.90 .75 .65 .55

Chart 6. (continued)

Material	R	K
Reinforced concrete (however, will not cut reinforcing steel)	Less than 3 feet 3 to 5 feet 5 to 7 feet More than 7 feet	1.40 1.10 1.00 .85

c. Tamping Factor

The value of the tamping factor (C) depends on the location and the tamping of the charge. Fig. 78 shows various methods of placing charges and gives values of C to be used in the breaching formulas with both tamped and untamped charges. No charge is considered to be fully tamped unless it is covered by material of at least radius depth.

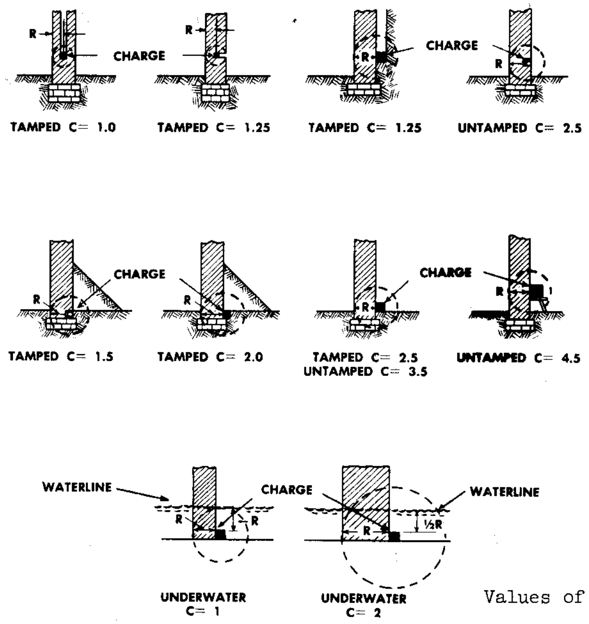


Figure 78

Values of "C" (Tamping Factor)

Example (see Fig. 79):

Applying these factors to the following example:

P = Pounds of TNT required

R = 2 feet

K (reinforced concrete) = 1.40

C (untamped) = 3.5

Substituting in the formula:

$P = \frac{R^3KC}{2}$

$P = \frac{(2)^3 \times 1.40 \times 3.5}{2}$

$P = \frac{39.2}{2}$

P = 18.6 lbs.

Since P is less than 50 lbs. it must be increased 10%:

18.6 x .10 = 1.86 lbs.

18.6 + 1.86 = 20.46 lbs.

Use 20.5 pounds of TNT per charge.

K' = Kilograms of TNT required

R = 6 decimeters

K (reinforced concrete) = 1.40

C (untamped) = 3.5

Substituting in the formula:

$K' = \frac{R^3KC}{2}$

$K' = \frac{(6)^3 \times 1.40 \times 3.5}{120}$

$K' = \frac{1058.4}{120}$

K' = 8.82 kg.

Since K' is less than 22.5 kg. it must be increased 10%:

8.82 x .10 = .88 kg.

8.82 + .88 = 9.7 kg.

Use 9.7 kilograms of TNT per charge.

PLACEMENT OF CHARGES FOR
REINFORCED CONCRETE BRIDGE

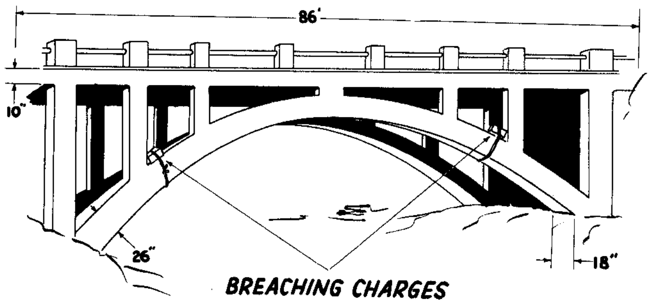


Figure 79

3. Formula for Breaching the Width of a Base

To determine the number of charges necessary to breach the base of the entire target, the following formula is used:

$$N = \frac{W}{2R}$$

N = Number of charges

W = Width of target in feet or decimeters

R = Breaching radius in feet or decimeters

Applying this formula to the previous problem (see Fig. 79):

$N = \frac{W}{2R}$

$N = \frac{8}{2 \times 2} = \frac{8}{4}$

N = 2

Therefore:

2 x 20.5 lbs. = 41 lbs.

Total explosive requirement is 41 pounds of TNT.

OR, for the metric system

$N = \frac{W}{2R}$

$N = \frac{24}{2 \times 6} = \frac{24}{12}$

N = 2

Therefore:

2 x 9.7 kg. = 19.4 kg.

Total explosive requirement is 19 kilograms of TNT.

4. Formulas for Internal Breaching Charges (See Fig. 80)

Shaped charges (see Section 12) may be used to punch boreholes for the placement of internal charges in concrete objects of great dimension. This of course is possible only when the object is in friendly hands, since the time required to prepare and load boreholes is considerable. Borehole charges should be closed with clay or moist earth.

Internal charges are calculated by means of the following breaching formulas:

$P = \frac{R^3KC}{2}$

P = Pounds of TNT required

R = 3 feet

K (ordinary concrete) = .7

C = 1.25

OR, for the metric system

$K' = \frac{R^3KC}{120}$

K' = Kilograms of TNT required

R = 9 decimeters

K (ordinary concrete) = .7

C = 1.25

Substituting in the formula:

$P = \frac{R^3KC}{2}$

$P = \frac{(3)^3 \times .7 \times 1.25}{2}$

$P = \frac{23.6}{2}$

$P = 11.8$ lbs.

Since P is less than 50 lbs. it must be increased 10%:

$11.8 \times .10 = 1.18$ lbs.

$11.8 + 1.18 = 12.98$ lbs.

Use 13 pounds of TNT per charge.

Substituting in the formula:

$K' = \frac{R^3KC}{120}$

$K' = \frac{(9)^3 \times .7 \times 1.25}{120}$

$K' = \frac{638}{120}$

$K' = 5.3$ kg.

Since K' is less than 22.5 kg. it must be increased 10%:

$5.3 \times .10 = .53$ kg.

$5.3 + .53 = 5.8$ kg.

Use 5.8 kilograms of TNT per charge.

The total explosive requirement is determined by N, the number of charges necessary to breach the base of the target. Substituting in the formula:

$N = \frac{W}{2R}$

$N = \frac{30}{2 \times 3} = \frac{30}{6}$

$N = 5$

Therefore:

5×13 lbs. = 65 lbs.

Total explosive requirement is 65 pounds of TNT.

OR, for the metric system

$N = \frac{W}{2R}$

$N = \frac{91}{2 \times 9} = \frac{91}{18}$

$N = 5$

Therefore:

5×5.8 kg. = 29 kg.

Total explosive requirement is 29 kilograms of TNT.

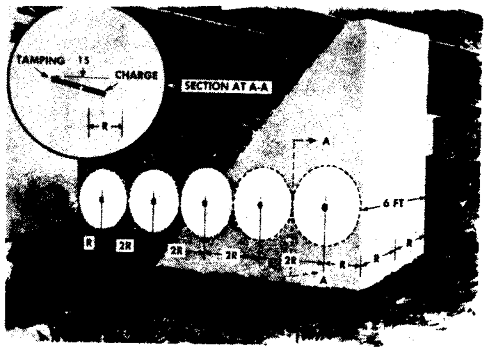


Figure 80

Borehole Pattern for

Breaching Concrete

5. Placement of Breaching Charges

Breaching charges should be secured to the target whenever possible. Where extremely large quantities of explosives are to be emplaced, this may be impossible. It is essential, however, that intimate contact of explosive with target exist. Fig. 81 shows some techniques for the placement of breaching charges.

6. Effects of High-Explosive Charges

High-explosive charges detonated in contact with concretelike materials deliver a shock so intense that the material breaks or shatters, strewing the area with high-velocity fragments. Personnel should be out of the impact area or under suitable overhead cover.

Charges placed on reinforced concrete affect only the concrete. Steel reinforcing rods, supports, or matting may bend under the stress of a detonation, and often the small rods closest to the charge will break, but all but these few supports will remain unbroken. This condition is only slightly changed by overcharging.

E. Cratering Charges

1. General

To be effective obstacles, road craters must be deep enough and wide enough to prevent the passage of vehicles through them. This generally means that there should be across the width of the road a ditch at least 5 feet deep and 15 feet wide, with wall slopes of 40° to 60°. Craters are effective on road fills over extremely marshy ground, defiles, and sidehill cuts. Tactically, they may suit the guerrilla in ambushes and delaying actions.

Cratering is not an operation that can be hastily executed. The preparation and loading of boreholes requires considerable labor, time, and materials (including the cratering explosive).

2. Road Cratering

It may be necessary to breach a hard-surface pavement in order to dig boreholes. This is effectively done by detonating tamped charges on the pavement surface. A 1-pound charge of TNT for each 2 inches of pavement thickness should be used and tamped with material twice as thick as the pavement. The boreholes should then be dug to a uniform depth, as is shown in Fig. 82. This depth should be a minimum of 4 feet. Notice that the boreholes are spaced 5 feet center-to-center across the road.

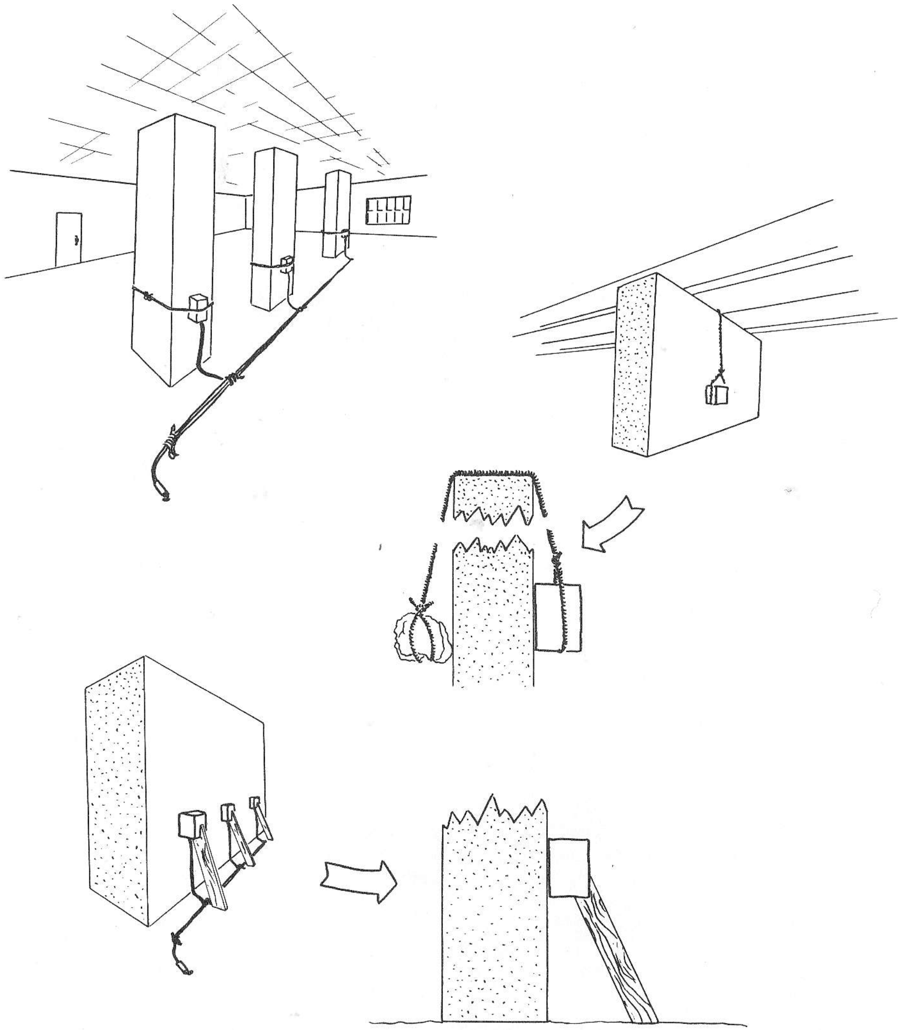


Figure 81

Placement of Breaching Charges

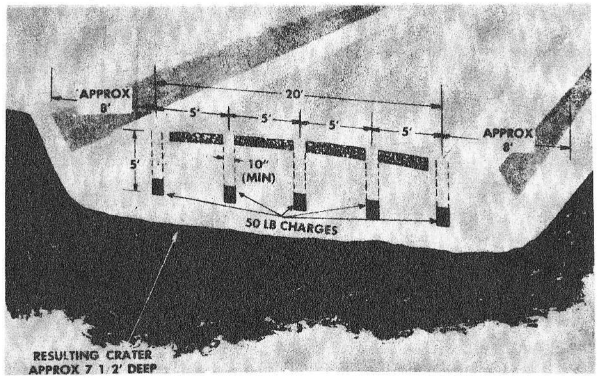


Figure 82

Borehole Pattern

for Road Crater

If the boreholes are dug with a post hole digger or are of small diameter, it may be necessary to spring (enlarge) them in order to pack the desired amount of explosive in them (see Fig. 83). Springing of boreholes is suitable only in hard, firm soil. The first springing charge should consist of not more than a pound of TNT. Spring charges are fired untamped. At least one-half hour between firing and placing of successive charges must be allowed for the hole to cool; or, if time is short, water may be poured into the hole, after which loading may proceed immediately. These latter precautions must be heeded, as serious accidental explosions have frequently occurred when they were ignored.

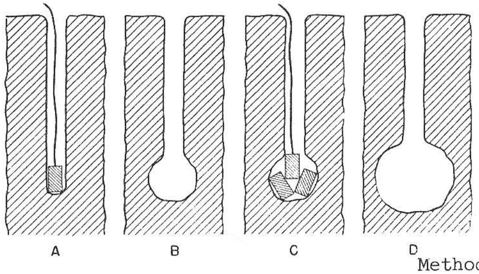


Figure 83

Method of Springing Boreholes

Shaped charges (see Section 12) may be used to fashion boreholes. The M2A3 shaped charge when fired from a 3-foot standoff distance will penetrate to a depth of 3 to 8 feet, depending on whether or

not it must first penetrate a hard-surface pavement. The type and condition of earth also influence the degree of penetration. Holes should be allowed to cool before they are loaded.

Load each borehole with 10 pounds of explosive per foot of borehole depth. Close the boreholes with earth and tamp it into the holes, being careful not to damage priming leads or wiring with the tamping stick.

3. Ambush Cratering

A single charge of 50 pounds of explosive placed in a 5-foot borehole in the center of an unpaved road will blow a tapered hole which is approximately 6 feet deep at the center and about 12 feet in diameter. The size will vary slightly according to soil conditions.

SECTION 9. FOREIGN EXPLOSIVES AND ACCESSORIES

A. General

Whenever possible, foreign explosives and accessories should be used to supplement dwindling stocks of domestic items. With the exception of certain minor differences, foreign material is similar to that with which you are familiar.

B. World's Principal Explosives

The composition of the majority of explosive compounds has been internationally known for years. Many countries compound such explosives as TNT, dynamite, plastics similar to C-4, and some of the other explosives that have previously been discussed in this chapter. The reason that one is prevalent in one country and nonexistent in another is primarily an economic consideration, e.g., a lack of substantial quantities of toluene in one country would limit or prevent that country's production of TNT and bring about the adoption of one or more substitutes.

The following chart indicates how commonplace our standard explosives really are. Although the chart has been compiled from the most accurate information available, there are noticeable gaps which may be filled as new data are acquired. The chart furnishes no information as to the size or form of the different explosives as they are packaged for issue. This is a minor consideration, since, obviously, explosives are issued in packages convenient for their intended use (e.g., ammonium nitrate, being a slow, nonpowerful, burden-heaving explosive, must be used in considerable quantity to be effective; it therefore is packed in units of several pounds or kilograms).

C. Characteristics of Foreign Explosives

Chart 7 reveals that many nations utilize those explosive compounds which scientists have determined are the most effective. A particular explosive compound produced by one nation is similar in characteristics to the same compound produced in another nation. Minor differences of purity, density, ingredients, etc. may influence the performance of an explosive slightly, but since all must stand the test of battle, the characteristics, particularly those of sensitivity and stability, must in general be the same.

Chart 7. World's Principal Explosives

	BRITISH	FRENCH	GERMAN	ITALIAN	JAPANESE	RUSSIAN
TNT	TNT *Trotyl	Tolite	Pull Pulver Sprengmunition 02	Tritolo *Tritdo	Chakatsuyaku	TOL *Trytyl
Cyclonite *C-3 *C-4	Plastic Explosive or *PE-2A		*Cyclonite *Hexogen C6 *Plastite *Nipolit	*Hexagene *T-4	Koshitsubakuyaku *Cyclonite *O-Shitsuyaku	Hexogen *Kamnikite
Tetryl *Tetrytol	Composition Explosive or C. E.				Meiayaku	TETP
PETN *Pentolite *Primacord (Det. Cord)	PETN *Pentolite *Cordtex (Det. Cord)		*Knallzundschur**		Shoe-i-yaku**	TEN *DSh 1943**
Ammonium Nitrate *Amatol	*Ammonal *Monobel (Australian)	Nitrate D'Ammonium *Tolite	Ammon Salpeter	Nitrato D'Ammonio *PNP *Schniderite *Tolual Amonal	Ammon Yaku *Shonayaku *Shoan *Gokuyaku	*Gromoboy *Ammonite *Dinomaonk *Maisite
Nitroglycerin *Dynamite *Blasting Gelatin	*Dynamite *Blasting Gelatin *Gelignite *Nobel's 808		*Dynamite		*Dainamaito	*Grisutine *Dynamon T
Picric Acid (TNP) (No longer used)	Picric Acid *Lyddite	*Melinite	Pikrinsaure	Acido Picrico *Pertite	Oshokuyaku *Shimose *Oshiyaku *Haishoyaku	*Melinyte
	Guncotton					Pyroxylin

* Compounded with other explosives.

** Not known whether this is demolition explosive or a detonating cord.

The following paragraphs are devoted to general discussions of the more common foreign explosives.

1. TNT

TNT is mixed with a variety of other explosives for both demolition charges and bursting charges for high-explosive shells. Among these are:

Pentolite--A 50-50 mixture with PETN.

Amatol--Mixed with varied proportions of ammonium nitrate.

Ammonal--A mixture with ammonium nitrate and aluminum powder.

TNT is issued in cast and granular form.

2. Plastic Explosives

So far as is known, no foreign-manufactured plastic explosive is as powerful as C-4, with the exception of the equally powerful British PE-2A. Nipolit (see Fig. 84), a German-developed plastic explosive, reportedly possessed unique qualities. It is claimed that this compound was issued in solid and flexible forms and that the latter appeared as belts, raincoats, etc. Its relative effectiveness was below that of TNT. Like C-3, it could be used as an incendiary and could be ignited with an ordinary match.

3. Picric Acid

TNP (Trinitrophenol) is slightly more powerful than TNT (velocity is about 23,000 fps). It has been gradually abandoned by practically every country except France and Japan. It is a lemon-yellow crystalline substance which may be identified by its tendency to dye water or whatever material it comes in contact with. It combines readily with some metals to form picrates (explosive salts) which are extremely sensitive to shock, friction, and heat. For this reason careful attention must be paid to packaging (usually paper or zinc is used) and storage. Otherwise, TNP has the same characteristics as TNT.

4. Guncotton

The power of guncotton (which is a cellulose of high nitration) is directly influenced by moisture content, i.e., dry guncotton may detonate at a velocity of 24,000 feet per second, whereas wet guncottom may detonate at about 18,000 feet per second. At the

Figure 84

same time, dry guncotton is extremely sensitive to shock, and so cannot be used for anything but booster pellets and blasting caps. The British 1-ounce, dry guncotton primer (booster pellet) is a greyish-white, center-drilled, cork-shaped, chalklike solid which is quite stable. The moistened guncotton demolition slab most nearly resembles a coarse grade of cellotex (soundproofing material). It deteriorates when exposed to air and is therefore shipped in sealed tins. It is so insensitive that a dry guncotton or CE (Tetryl) booster pellet is required to detonate it.

5. Nitroglycerin Explosives

The straight, ammonia, and gelatin (gelignite) dynamites described in Section 2. are not uncommon in foreign countries.

Granular or free-running dynamite is convenient for borehole loading and replaces black powder in some areas of the world. It usually is less sensitive than other dynamites because of the increase of ammonium nitrate or other compound necessary to make it pour.

Nobel's 808 is very like blasting gelatin, being of a higher density and somewhat less sensitive. It has a hard, rubberlike texture which tends to soften as the temperature is increased. Its color normally varies between green and brown. The British employed 808 as a military explosive during World War II even though it sometimes detonated when struck by a rifle bullet.

D. Other Equipment

1. Primers

Many foreign explosives are as insensitive to shock as issue TNT. Since most foreign blasting caps are equivalent to the standard No. 6 and No. 8 caps, the insensitive explosives cannot be detonated consistently by the caps alone. A small amount of a more sensitive explosive must be used as the link between the charge and the cap; this is commonly referred to as a booster pellet or primer. Foreign demolition charges of the cast type requiring the use of a primer are manufactured with an integral primer recess.

British primers are of dry guncotton or tetryl. Both weigh 1 ounce, are cork shaped, and are recessed to take the standard No. 8 detonator.

2. Detonating Cord

Detonating cords are widely employed in commercial blasting and military demolitions. They may consist of PETN, TNT, or other explosive compounds. They are covered with textile, plastic, lead, or other materials. Their velocity of detonation may lag behind or surpass that of primacord. Excessive bending and kinking should be avoided, since such handling may break the explosive train and cause misfires.

3. Blasting Caps

Foreign blasting caps may be identical to the No. 6 and No. 8 caps described in Section 3., or they may be of dry guncotton or some other compound pressed into a cardboard or paper shell similar to one of the Russian types. They may be of a slightly different length and/or diameter. As far as is known, there is no foreign equivalent of the Special blasting cap.

4. Burning Fuse

It is important to recognize instantaneous fuse. Many countries provide this for booby-trapping and incendiary purposes. It burns at incredible speeds -- some types as fast as 200 feet per second. When ignited it may appear to explode rather than burn, depending, of course, on its speed. In order that accidents be minimized, all black-cored fuse should be tested before being used with explosives. Light unidentified fuse with a device which will permit ignition from a safe distance.

The British instantaneous fuse (Cordtex), which is orange and red in color, burns at the rate of about 120 feet per second.

E. Handling Foreign Explosives

The characteristics of an unknown explosive must never be assumed or taken for granted. Before the explosive is subjected to the expedient-test methods outlined below, the user should endeavor to learn about the explosive's characteristics by referring to as many sources as his time and situation permit. In testing an unknown explosive the user should:

1. Examine the packaged unit (case, block, cartridge) for exuded liquids. If there is reason to believe that an "oozing" explosive is a dynamite (i.e., contains considerable nitroglycerin) it should be destroyed (see Section 6.).

2. Subject a mass of about a pound of the explosive to the fire of a military-type rifle. If after five or more hits the explosive fails to detonate, it may be considered to be insensitive to shock and friction for the time being. Dynamites should detonate on the strike of a bullet. The decision as to whether or not a sensitive explosive should be used for training and operations will, of course, be influenced by the situation, availability of other material, etc.

3. Subject about an ounce of the explosive to flame by placing it on paper or some other combustible and igniting the paper or combustible. (This permits the tester to withdraw to a safe observation point before the flame reaches the explosive.) Take note of the following burning characteristics: color of flame, rate of burning, whether or not the explosive melts, amount and color of smoke, etc. These may be similar to the burning qualities of known explosives and may therefore afford an indication as to the content of the unknown explosive compound.

The unknown explosive should be re-tested periodically in order that its stability may be determined.

If it is ascertained that an explosive is reasonably safe to handle, its performance characteristics must be determined, i.e., its insensitivity, power, etc.

4. Attempt to detonate a unit of the unknown explosive with a single blasting cap. If this fails, increase the number of blasting caps by one for each successive attempt until detonation occurs. Blasting cap clusters should be fashioned as is shown in Fig. 85. As an alternative, the detonating cord priming technique is suggested (see Section 7.).

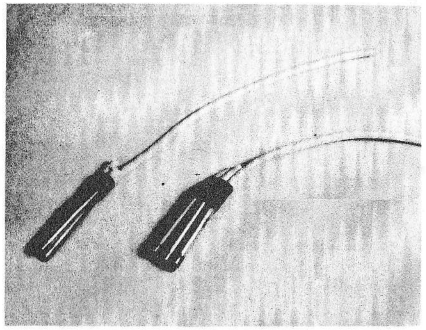


Figure 85

In order that a low-order detonation not be accepted as the power peak of an explosive, the explosion report, the amount and color of smoke, and the resulting damage to the object in contact with the explosive should be noted. Low-order detonation is variously described as being similar to deflagration, a partial detonation, a detonation of the more sensitive components of an explosive compound, etc. A modulated report, excessive, billowing smoke, (color varies with different explosives) and little or no target damage indicate a low-order detonation. To gain a high-order detonation, increase the number of blasting caps or amount of detonating cord previously used.

Establish the relative effectiveness of the unknown explosive by comparing its cutting, breaching, and heaving capabilities with those of known explosives.

SECTION 10. MINES, BOMBS, AND EXPLOSIVE PROJECTILES AS DEMOLITION CHARGES

A. General

The use of land mines, aerial bombs, and explosive projectiles as demolition charges is generally uneconomical, but may at times become necessary or desirable. Such material may be either captured or friendly supply stocks or, in the case of mines, may have been recovered from minefields. These items are loaded with an insensitive high explosive such as TNT, TNP, etc. Untrained personnel should never attempt to remove the explosive from a mine, bomb, or shell. "Duds" should never be used for demolition purposes. The use of mines, bombs, or shells as demolition explosives makes special precautions necessary in order that personnel be protected from fragments of flying steel.

Most general-purpose bombs and land mines contain explosives equal to approximately half their total weight. The ratio of explosive weight to the total weight of fragmentation bombs, artillery shells, mortar ammunition, etc., is very small, and so their use for demolition purposes is not recommended. Only the actual explosive weight of a mine, bomb, or shell should be considered when calculating the size of a charge. Also, since contact of charge with target will depend on the shapes involved and therefore be generally poor, considerable overcharging may be necessary. Test shots will indicate the results that can be expected.

B. Land Mines

Only defused mines should be used in demolition charges. If field personnel are not acquainted with the characteristics, defusing, and booby-trapping of a particular emplaced mine, it should not be touched. Fused mines may be extremely sensitive and may detonate with even normal handling.

Mines should be primed with a half-pound of explosive placed in intimate contact with a flat surface, as is shown in Fig. 86. When several mines are to be detonated as a single charge, it is advisable to prime at least two of them even though an explosion of one would normally detonate all others in contact with it.

C. Aerial Bombs

General-purpose and demolition bombs may be used satisfactorily for demolition charges, but are most effective as cratering charges.

Bombs are shipped and stored unfused; the fuse recess is closed by a threaded shipping plug and is not removed until just prior to the time the bomb is loaded aboard an aircraft. Chart 8 gives the weight of high explosive contained in general-purpose bombs of various sizes.

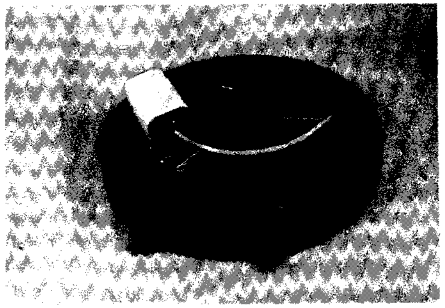


Figure 86

Chart 8. Explosive Content of General-Purpose Bombs

Bomb	Explosive Weight (in pounds)
100 lb. GP, AN-M 30	57
250 lb. GP, AN-M 57	129
300 lb. GP, M 31	144
500 lb. GP, AN-M 43	267
1000 lb. GP, AN-M 44	558
2000 lb. GP, AN-M 34	1117

All bombs may be primed with small shaped charges (see Section 12.); otherwise, bombs under 500 pounds should be primed with a 5-pound explosive charge placed against the middle of the body of the bomb; heavier bombs should be primed with a 10-pound charge similarly placed.

In testing to see whether or not a particular bomb is the equivalent of a domestic general-purpose bomb or a fragmentation, smoke, or chemical bomb, the size of the primer should be increased and a test shot made. To ensure detonation, large bombs should be primed separately.

D. Explosive Projectiles

Mortar ammunition, rockets, and small artillery shells (105 mm. and smaller) contain very little high explosive and are therefore generally unsuitable for demolition purposes. The 155 mm. H.E. shell contains 15 pounds of explosive. The 240 mm. H.E. shell contains about 50 pounds of explosive. All shells may be primed with small shaped charges (see Section 12.); otherwise shells up to 240 mm. should be primed with 2 pounds of explosive placed in contact with the casing just forward of the rotating band, as is shown in Fig. 87. To assure detonation, individual shells must be separately primed.

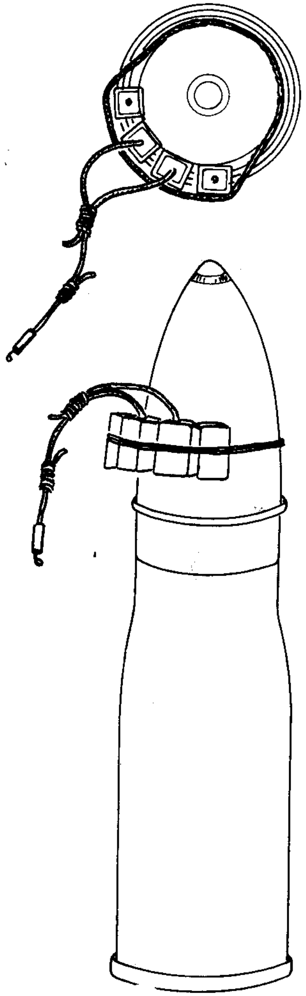


Figure 87

Method of Priming Artillery Projectile

SECTION 11. HOMEMADE EXPLOSIVES

A. General

The compounding of high explosives is not so simple a task that it can be undertaken by field personnel with improvised equipment. In addition to the hazards involved, considerable quantities of special chemicals and certain laboratory equipment are needed. Instructions on this subject are not included in this manual because of the high degree of hazard and specialization involved.

CAUTION: After the saboteur has located the necessary chemicals and other supplies, made the acquaintance of individuals working in these plants, and arranged to receive these chemicals, he should not put the materials into actual use until he has at hand sufficient chemicals for all the operations he is planning. Otherwise, if operations are commenced on a small scale, the enemy may place severe restrictions on certain critical materials and they may become inaccessible for further operations.

The homemade explosives described in this chapter are low explosives composed of deflagrating agents. They will serve many sabotage and guerrilla purposes such as improvised grenade fillers, cratering charges, etc., but are ineffectual where cutting or breaching is desired. Low explosives must be strongly confined or tamped -- otherwise, they will flash without explosive violence. Low explosives are flame or spark ignited. Low explosives are generally unstable, being affected by moisture in almost all cases.

B. The Explosive Mixture

1. Chemicals Required

The recommended explosive mixtures contain two ingredients: a compound rich in oxygen, and some substance which, when combined with oxygen, will react so quickly that an explosion results. The reaction, of course, is dependent upon flame or heat. The names of some very common materials which may be used in making explosive mixtures are given in Chart 9.

2. Sources of Chemicals

Ammonium nitrate is used in the manufacture of explosives, pyrotechnics, fertilizers and insecticides.

Chart 9. Components for Homemade Explosives

Oxygen-rich Compounds	Combustibles Which React With Oxygen
Ammonium Nitrate	Aluminum Powder
Potassium Nitrate	Magnesium Powder
Sodium Nitrate	Charcoal-Sulfur Mixture
Potassium Chlorate	Charcoal
Sodium Chlorate	Sugar
Potassium Permanganate	Coal, Sawdust, Flour, Starch, Cork Dust — With or Without Oil

Potassium nitrate is used industrially in the manufacture of explosives, pyrotechnics, matches, and glass. It also is used as a refrigerant, as a rust inhibitor, for the tempering and bluing of steel, and in the pickling of meat.

Sodium nitrate is used in fertilizer, pyrotechnics, and fluxes. It is a source of nitric acid, a catalyst in the production of sulfuric acid, and a coagulant in the manufacture of rubber latex.

Potassium chlorate is used in the manufacture of explosives, pyrotechnics, and matches. Also, it is sometimes employed in printing and dyeing processes.

Sodium chlorate is used in the manufacture of matches and weed killers. It is also used in dyeing and tanning processes.

Potassium permanganate is used medically and as a disinfectant. Industrially, it is employed in chemical industries as an oxidizer and is sometimes used in textile bleaching.

3. Ratio of Oxygen-Rich Compound to Combustible

Two different explosive mixtures are:

1. 80 parts ammonium nitrate with 20 parts aluminum powder.

2. 80 parts potassium chlorate with 20 parts charcoal or sugar.

Notice that in both cases 80 parts by weight of the oxygen-rich compound is mixed with 20 parts by weight of the combustible substance. In fact, 80 parts of any oxygen-rich compound listed in Chart 9 mixed with 20 parts of any combustible listed in that Chart will produce an explosive mixture. But no mixture should be assumed to be suitable; it must be subjected to several test shots.

4. Making the Explosive Mixture (See Fig. 88.)

The following steps should be followed in sequence:

1. Grind each chemical into powder separately. Unless ingredient chemicals are thoroughly dry and powdered, an unsatisfactory performance is bound to result. Be sure to grind the chemicals separately in a clean wooden, glass, or pottery bowl using a wooden stick or mallet. Never use sparking utensils, since a spark might ignite the mixture. After one substance has been ground, the bowl must be thoroughly cleansed before another substance is put into it. Grind the ingredients firmly but keep the face away from the bowl, for ignition is not impossible.

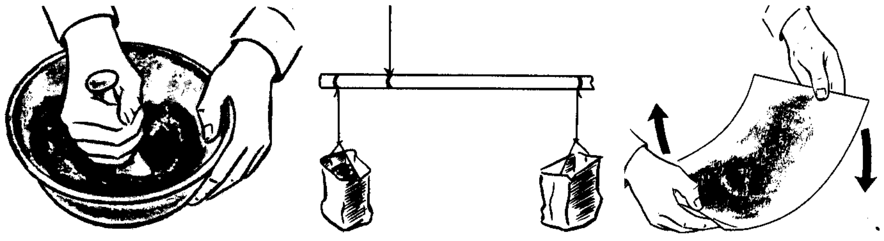
2. The proper proportions of ingredients are determined by the use of a simple balance which may be constructed as follows:

   Suspend an empty cup or bag from either end of a 10-inch stick which has a hole in it 2 inches from one end. Pass a string through the hole in the stick and attach the string to some object so that the stick is suspended by the string. Place the oxygen-rich compound in the cup or bag nearest the hole in the stick and place the combustible material in the cup or bag at the other end of the stick. When balance is established, the ratio of weights is 80:20.

3. Mix the ingredients by placing them on a large sheet of paper. Stir the mixture with a nonsparking tool and then raise and lower the corners of the paper. This process should be continued for several minutes. Mixing should take place just

before the explosive is used. Under no circumstances should homemade mixtures be stored for more than a day or two; this is especially important in the case of chlorates, which become dangerous if stored longer.

4. The mixture is then ready to be loaded into the charge container.



A B C

Figure 88. Preparing and Mixing Homemade Explosives

C. Black Powder

Homemade black powder is generally less dependable than those mixtures described above, because of the difficulty in producing a uniform granule size. Black powder results from mixing potassium nitrate, charcoal, and sulfur in the following proportions: 80:10:10 by weight.

1. Preparing and Mixing Black Powder

a. Grind the ingredients separately, as for the previous mixture.

b. Thoroughly mix equal weights of sulfur and carbon. (An improvised scale can be made by hanging cups on the ends of a stick, and suspending the stick from some object by a string tied midway between the two cups.)

c. Using the 10-inch balance described above, place the sulfur-carbon mixture in the cup which is 8 inches from the suspending string, and balance it with potassium nitrate placed in the other cup.

d. Mix the ingredients from c. The mixture will now contain 10 parts of sulfur, 10 parts of carbon, and 80 parts of potassium nitrate.

e. Place the mixture in a nonsparking bowl and add only enough water to make the ingredients cake.

f. Press the resultant mixture into a flat cake between two boards or similar flat surfaces and then leave it there for several hours.

g. Break up the dried cake with a wooden mallet or nonsparking tool until it is completely granulated.

h. Pass the granules through a screen. The proper-size granules are those which pass through a 10-mesh (.04- to .08-inch opening) screen but are held by a 20-mesh (.02- to .04-inch opening) screen. Granules that are too small or too large are returned to a bowl and the moistening, pressing, etc., processes repeated.

i. Dry the proper-size granules at room temperature or in sunlight for many hours.

j. The mixture is ready to be loaded into the charge container.

(Note: Sodium nitrate may be substituted for potassium nitrate in the above-described procedure, but the resultant mixture will be very hygroscopic, which means that it will absorb moisture from the air and that caking will occur. Any fine powder present in the mixture increases the burning speed of the mixture.)

D. Containers for the Charge

1. Fragmentation Grenades

A brass, aluminum, copper, or lead pipe about 3 to 8 inches long and 1 to 2 inches in diameter should be used. Iron or steel pipe is less satisfactory because the homemade mixtures are not powerful enough to cause these to shatter sufficiently. One end of the pipe should be capped or flattened and folded, as is shown in Fig. 89, before the mixture is loaded. After it is loaded and tamped, the grenade is closed with a threaded cap drilled to take the priming fuse or the pipe is flattened and folded as previously memtioned. The latter technique must be done carefully in order to prevent sparking. The latter technique also requires that a fuse recess be drilled in the side of the container before the container is loaded. The fuse recess should then be taped or covered over from the inside. When the grenade is to be primed the tape or cover is punched through and the fuse inserted (see Fig. 89).

Figure 89

2. Cratering Charges

Large charges of homemade explosives should be packed in large tins, small drums, or wooden boxes. Before a charge is placed in a borehole it should be moistureproofed or waterproofed, depending upon conditions. Where large quantities of deflagrating explosives are used, the container itself provides little confinement. It is therefore necessary that such charges be properly tamped.

E. Homemade Fuse

When issue safety fuse is not available, homemade string fuse may serve the purpose.

1. Materials Required

a. A shoelace or thick cotton string.

b. A 25-percent solution of potassium nitrate.

2. Preparation

a. Wash the shoelace or string in hot soapy water to remove oil, dirt, etc., and rinse it thoroughly in fresh water.

b. Place the shoelace or string in the boiling potassium nitrate solution and leave it for about 30 minutes. Stir occasionally to remove bubbles of air.

c. Hang the fuse up to dry; do not wring it out. It will dry thoroughly in a warm oven in 4 hours.

(Note: Potassium chlorate may be substituted for the potassium nitrate, but the burning time for the resulting product is less reliable. If potassium chlorate is used, 2 teaspoonfuls of it should be dissolved in a cupful of boiling water. Stir and keep hot for 20 minutes, after which time the chlorate is completely dissolved. Proceed as above.)

3. Characteristics of String Fuse

String fuse burns very slowly, (about 1 to 2 minutes per foot); if it burns too fast, use diluted solutions in making up another batch. In using the fuse, set it in a straight line or a wide curve. Lengths of string fuse may be spliced with simple knots, but the fuse cannot be handled excessively, for handling causes the flammable particles to drop off. When ignited, the fuse smolders; if the operation is carried out at night, the glowing end of the string fuse is visible, a disadvantage which can be overcome by burning the fuse inside a section of bamboo rod or pipe.

String fuse may be moistureproofed with collodion, which is used for medical purposes and is used industrially in processes such as photography and process engraving and in products such as cement and patent and artificial leather. However, only fuse prepared with a potassium nitrate solution can be moistureproofed. After the impregnated fuse has dried, it is soaked in the collodion solution. Excess collodion is squeezed out by pulling the fuse between the fingers; after this is done the fuse is dried again.

If string fuse is unsuitable, various expedients such as blackpowder trains, twisted paper, oil-soaked rope, punk, joss sticks, cigarettes, candles, etc., may be substituted. Improvisations always be tested under field conditions.

SECTION 12. SHAPED CHARGES

A. General

A shaped charge (see Fig. 90) is an explosive mass which is so shaped that when detonation of the charge occurs the explosive energy is concentrated in one direction. This feature -- known as the "Monroe effect" -- gives the shaped charge a greater penetrating effect than ordinary charges and thus makes it most useful for the blasting of boreholes and the cutting of steel, concrete, or similar material.

Diagram A shows that any flat-sided charge which is detonated while in contact with steel will produce a basin-shaped indentation.

Diagram B shows that the same charge with a simple cavity fashioned in its target-end will cause an increase in penetration regardless of the geometric shape of the cavity.

Diagram C shows that penetration is increased further when the cavity is lined with a material (e.g., copper) which has a low melting point.

Diagram D indicates that maximum penetration results when the shaped charge with cavity liner is detonated a short distance from the target.

Each of the charges shown consists of the same weight and kind of explosive. It is therefore quite obvious that substantial economy of explosive is effected when shaped charges are used for penetration purposes.

Targets such as electric motors, generators, transformers, steam turbines, and various types of pumps, as well as other apparatuses may be irreparably damaged by small shaped charges.

B. Theory of Shaped Charge

The existence of a shaped cavity in one end of an explosive charge causes a directional development of explosive energy which occurs simultaneously with detonation. This directional force results from the high velocity of the gaseous and semigaseous molecules within the cavity. The force leaving the surface of any detonated explosive falls off rapidly at even a short distance from the explosive. This is not the case within the cavity of a shaped charge, where there is an actual increase in the velocity of the expanding gas.

A logical assumption as to why this occurs is (see Fig. 91) that the shock transmitted to the shaped charge by a blasting cap causes a

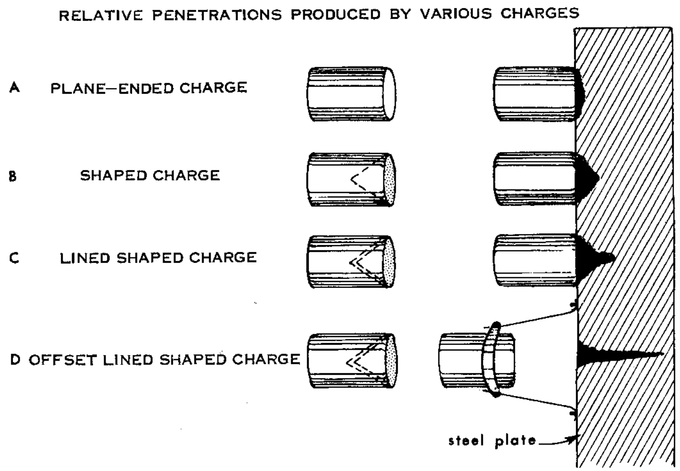


Figure 90

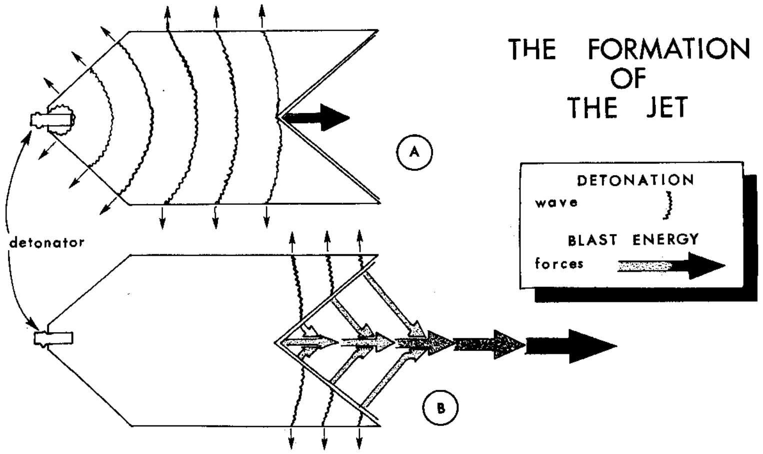


Figure 91

detonating wave to proceed downward and outward through the explosive at uniform speed. The descending detonating wave-fronts first come in contact with the cavity liner apex. The temperature at the cavity liner during detonation is normally from 1,800° to 3,600° F; the velocity of the explosive normally ranges between 20,000 and 28,000 feet per second. Confronted by the extremely hot and rapid detonating wave-fronts, the portions of the liner nearest the apex squirt forward as minute fragments, molten matter, and even vapors. Coincident with this action, the ever descending detonating wave-fronts reach lower and lower planes of the cavity liner. This tends to cause compression toward the center of the cavity, thereby adding to the impetus of the jet. The front of this jet is composed of highly dense gas and solid particles moving at speeds of 20,000 to 30,000 feet per second. This is followed by slower moving fragments, the residue of the highly compressed liner and fragments torn from the skirt of the liner.

Penetration is achieved when the high-velocity jet gases and particles strike a target somewhat in the manner that a stream of machinegun bullets entering the same hole would penetrate an earth bunker. Stated technically, the concentrated force of the jet makes an indentation in the target which is enlarged by radial pressure. This causes detrusion or plastic deformation of the target. Unless the jet penetrates the target there is no loss of target weight and the material is merely pushed out of the jet's path. On the other hand, if the jet is capable of penetrating the target, the pressure will at some point be sufficient to force out a plug of target material. Spalling (chipping) may occur as the plug breaks through the back surface. The jet, after it has pierced a target, may still exhibit considerable residual energy.

C. Characteristics of Shaped Charges

The design of a shaped charge is complicated by the interdependence of many factors which are discussed below. In many cases, particularly in homemade shaped charges, jet efficiency must be compromised by considerations involving one or more of these factors, with a resultant reduction of performance.

1. Symmetry

The symmetry of a shaped charge about a central axis is of great importance. This includes physical and metallurgical uniformity of the liner, physical and chemical uniformity of the explosive, and symmetry of detonation.

2. Liner Considerations

Shaped-charge liners have been fabricated in many shapes and of a great variety of materials. For deep penetration, copper linings give maximum performance. Cadmium, zinc, mild steel, aluminum, and glass also assure satisfactory results. Most cavity liners are of a conical shape and have apex angles of 30° to 60°. The apex is usually rounded because of manufacturing considerations. The thickness of the cavity liner should be uniform and should be proportional to the weight of the charge.

3. High-Explosive Fillers

Generally speaking, the more brisant explosives are the best for shaped charges. Among the explosives used in shaped charges are: Composition B (a cast mixture of RDX, TNT, and wax) and Pentolite (a cast mixture of PETN and TNT). For improvised shaped charges, Compositions C-3 and C-4 give good results.

4. Standoff

Standoff is the term used to define the airspace between the base of the shaped-charge liner and the target. This space is necessary to allow formation of the jet, and any hindering material in this space will markedly reduce penetration. In shaped charges with conical liners, standoff for optimum performance increases in direct proportion to increases in the apex angle.

D. Prepared Shaped Charges

1. Demolition Shaped Charges (See Fig. 92.)

Container	Plastic
Liner Material	Copper
Liner shape	Cone
Liner angle	60°
Liner thickness	.050 inches
Explosive	$4\frac{1}{2}$ ounces of Desensitized RDX

Standoff is provided by that portion of the plastic container below the crease.

The demolition shaped charge may be expected to penetrate from 7 to 10 inches of mild steel.

The charge is primed by affixing a blasting cap to the reinforced detonating cord priming lead with tape.

(Note: The detonating cord priming lead must be carefully handled to avoid kinking. When the blasting cap is attached, the priming lead should not be allowed to sag below the level of the top of the charge.)

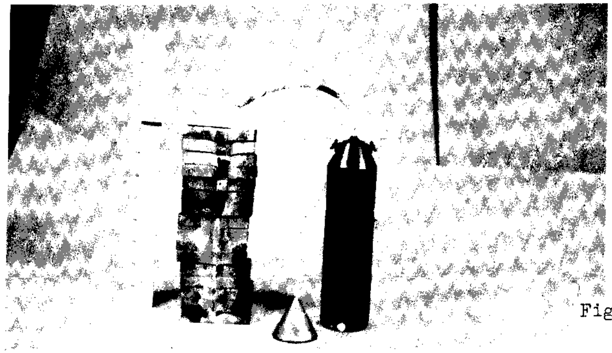


Figure 92

2. Shaped Charge, 15-lb. M2A3 (See Fig. 93.)

Container	Molded fiber
Liner material	High-density glass
Liner shape	Cone
Liner angle	60°
Liner thickness	0.36 inches
Explosive	$11\frac{1}{2}$ pounds of 50-50 Pentolite or Composition B

Standoff in provided by the molded fiber sleeve.

The M2A3 charge may be expected to perforate completely a 3-foot-thick wall of reinforced concrete or 1 foot of armor plate.

The M2A3 charge is primed with the Special blasting cap; the blasting cap recesses are threaded to take priming adapters.

The M2A3 charge is too large for it to be considered an ideal sabotage weapon. There may be isolated instances, however, in which it might be used for punching boreholes in massive concrete structures. Such boreholes would then be loaded with breaching charges.

Although this charge contains no metal parts (with the exception of the closing cap and detonator well) it is advisable that personnel be under cover and at least 100 yards away from the charge at the time of the blast.

3. Shaped Charge, 40-lb. M3 (See Fig. 94.)

Container	Sheet steel
Liner material	Mild steel
Liner shape	Cone
Liner angle	60°
Liner thickness	0.15 inches
Explosive	$29\frac{1}{2}$ pounds of 50-50 Pentolite or 30 pounds of Composition B.

Standoff is provided by the detachable stand.

The M3 charge may be expected to penetrate a 5-foot-thick wall of reinforced concrete (see Fig. 95) or 20 inches of armor plate. The M3 charge is primed in the same fashion as is the M2A3 charge, and is used against the same targets (see Fig. 95). As previously stated, such operations require considerable time and material and would therefore apply more to a denial program than to sabotage.

Heavy shaped charges may also be used to punch cratering charge boreholes (see Fig. 96). The charges should be placed 2 to 4 feet above the road surface in order to minimize surface damage. By placing them directly on the surface, the surface concussion is more apt to remove a cubic yard or two of soil or cause the concrete or other hard surface surrounding the borehole to flake or spall (see Fig. 95). All boreholes should be cooled before being loaded with other explosives.

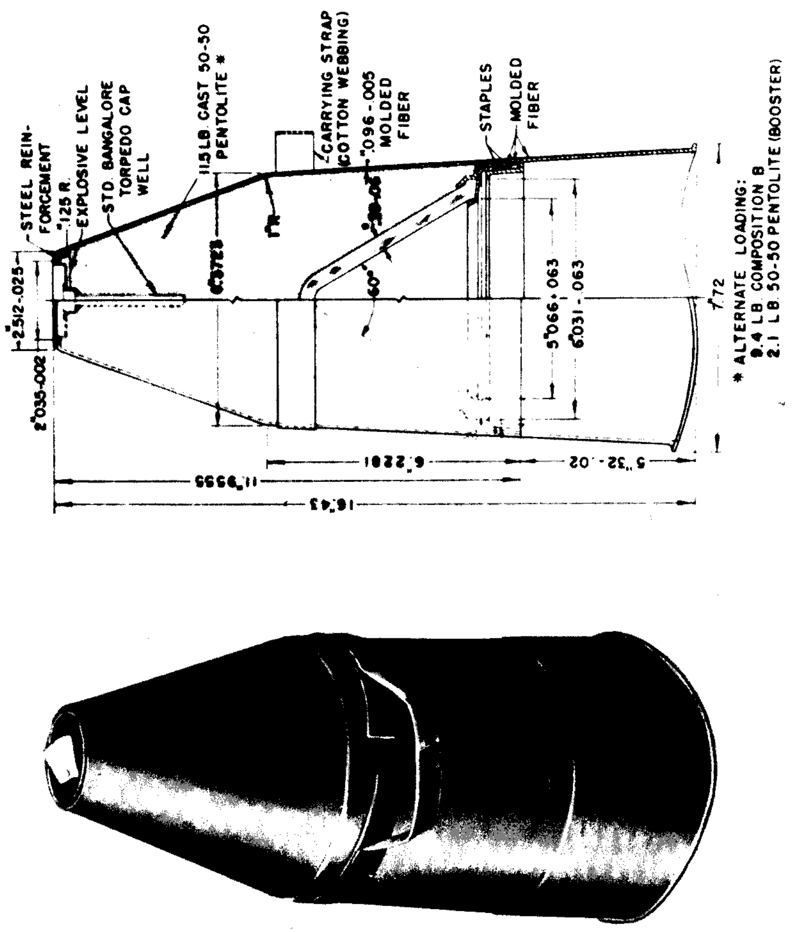


Figure 93

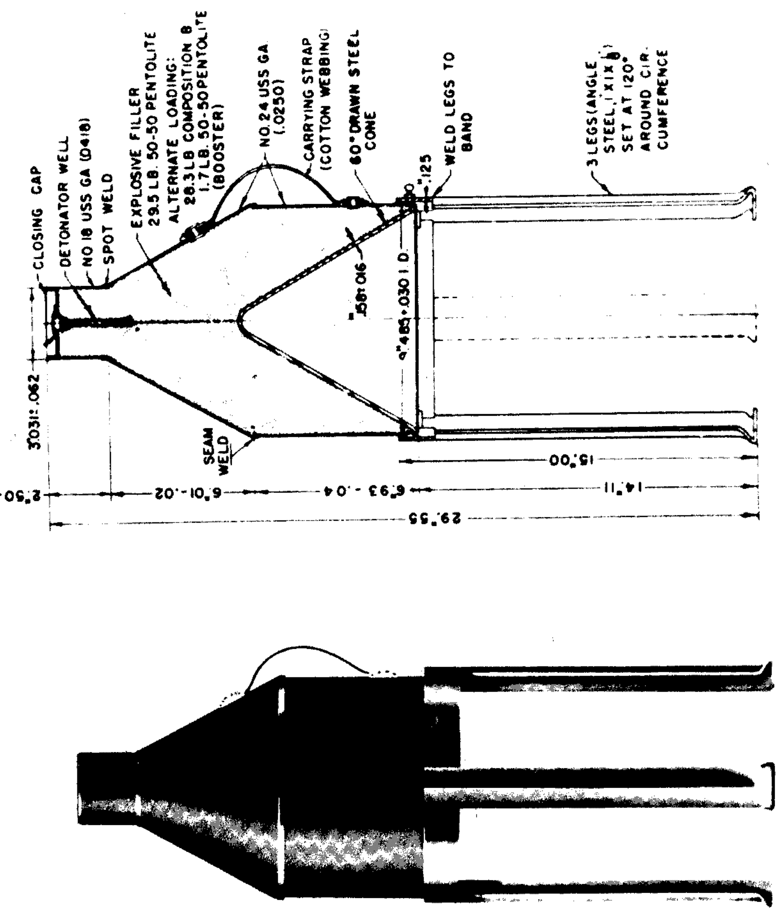


Figure 94

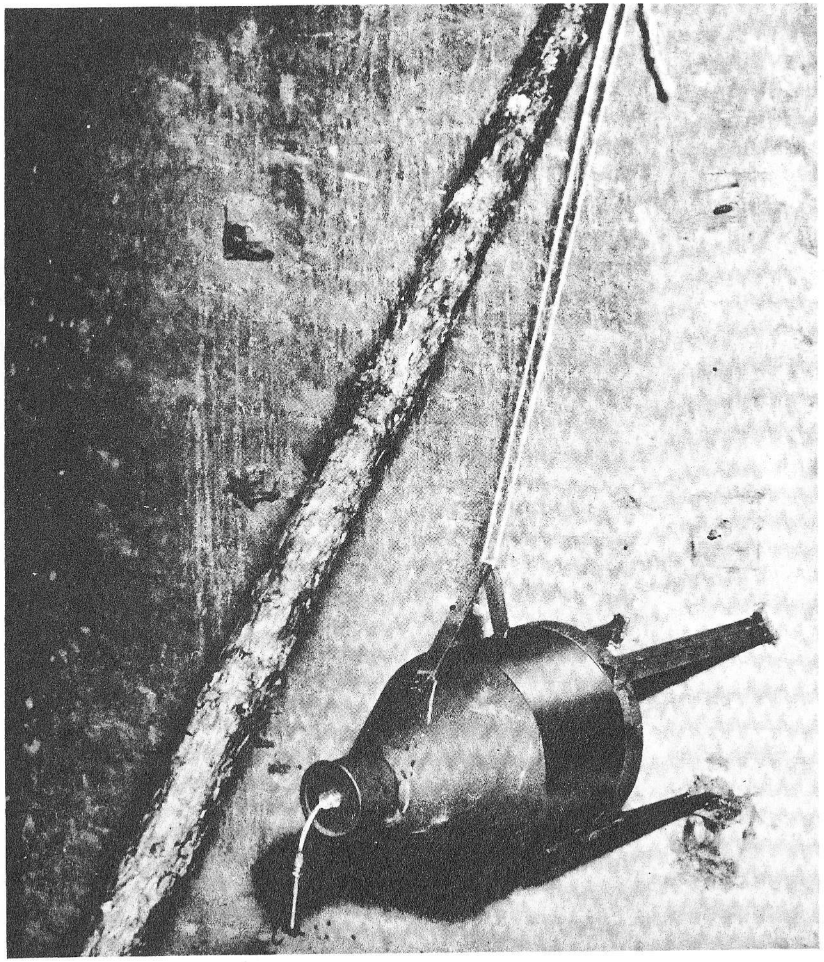


Figure 95 A

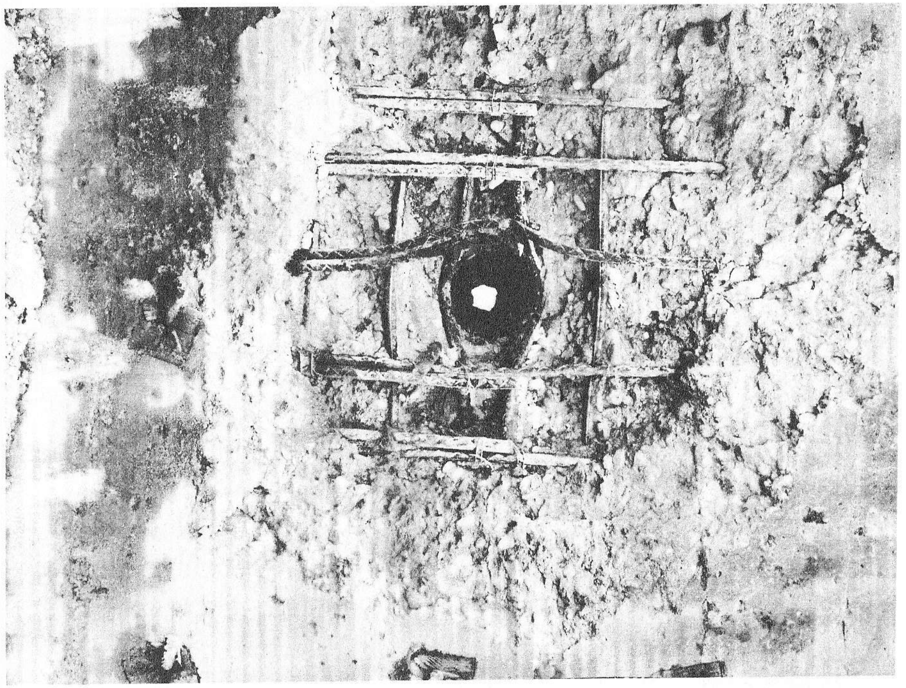


Figure 95 B

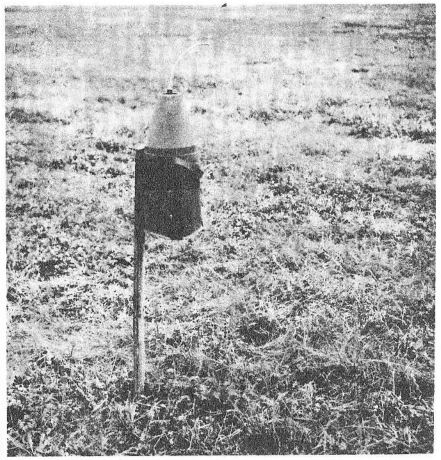


Figure 96 A

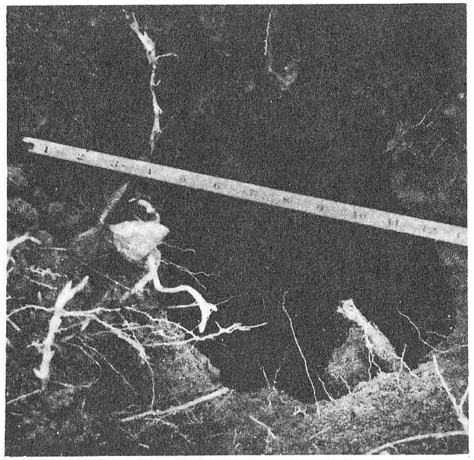


Figure 96 B

Large shaped charges may be adapted to serve as anti-personnel weapons in ambush operations. The cavity of the charge should be loaded with miscellaneous bits of metal (nuts, bolts, nails, rocks, etc.) and then the mouth of the cavity should be covered with cardboard or fabric to prevent loss of the bits of metal while the charge is being transported or emplaced. The charge should be placed with the cavity facing the longitudinal axis of a probable target; ideally, it should be 4 to 6 feet above the surface on which the target is expected to move. It should be carefully aimed and then anchored with a sandbag. When the charge is detonated, the metal in the cavity will be hurled out at high velocity and will cut a cone-shaped swath in anything in front of it. The metal will have lethal force for a range of more than 50 yards.

E. Adapting Shaped Projectiles for Sabotage Purposes

Shaped charge antitank rockets and artillery projectiles make ideal sabotage charges. But since there is little possibility that symmetrical detonation can be induced by the detonation of a primer placed against the case or body of the projectile, the projectile will have to be partially disassembled. This is not a hazardous operation as long as the recommended procedures are followed.

The characteristics of several shaped-charge projectiles are described below, along with instructions for dismantling and priming them.

1. Rifle Grenade, AT, M9A1 (See Fig. 97.)

   a. Characteristics

Container	Sheet steel
Liner Material	Mild steel
Liner Shape	Cone
Liner Angle	44°
Liner Thickness	.036 inches
Explosive	$\frac{1}{4}$ pound of 50-50 Pentolite.

   The M9A1 grenade will penetrate $3\frac{1}{2}$ inches of armor plate or 5-9 inches of mild steel.

   b. Disassembly (See Fig. 98.)

   (1) Wrap tape around the safety clip to prevent accidental removal of the safety pin.

   (2) Lock with a pipe wrench or vise, as is shown in Diagram A.

   (3) File or saw through the peen mark that locks the stabilizer to the head (see Diagram B).

   (4) Remove the head component by unscrewing it in a counterclockwise direction (see Diagram C).

   This is as far as disassembly need proceed. Move the stabilizer -- which contains the firing train, including the detonator and booster pellet -- to a disposal area.

   c. Priming Technique (See Fig. 99.)

   (1) Fashion a cardboard sleeve to fit over the head of the charge.

   (2) Pack a $\frac{1}{4}$ pound charge of C-3 or C-4 into the sleeve and tamp it against the booster, leaving sufficient room for the insertion of a triple-roll knot of detonating cord or a blasting cap.

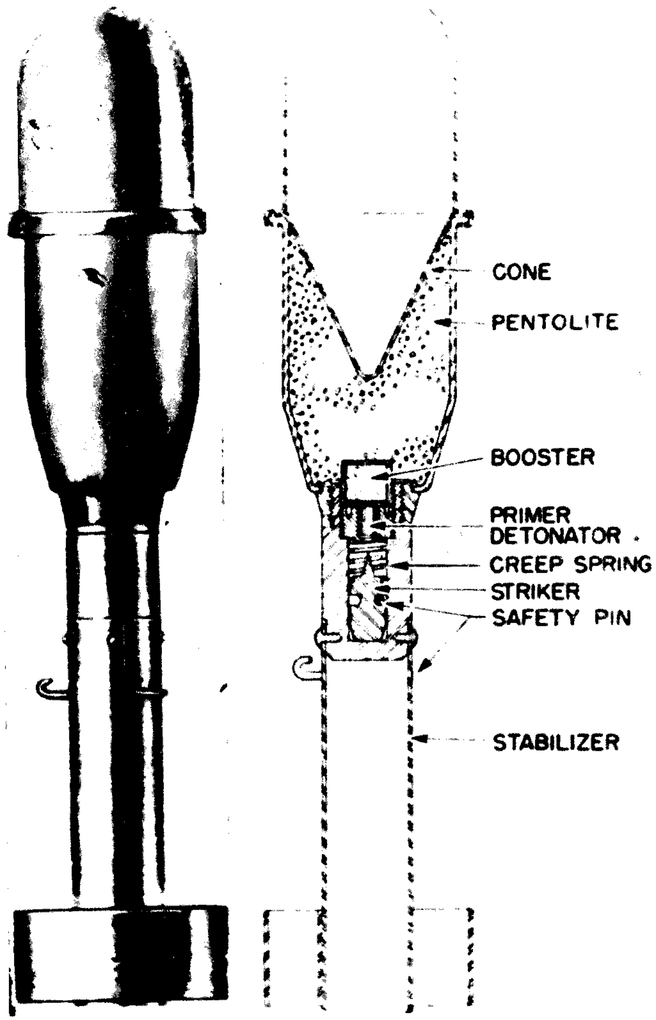


Figure 97

Figure 98 A

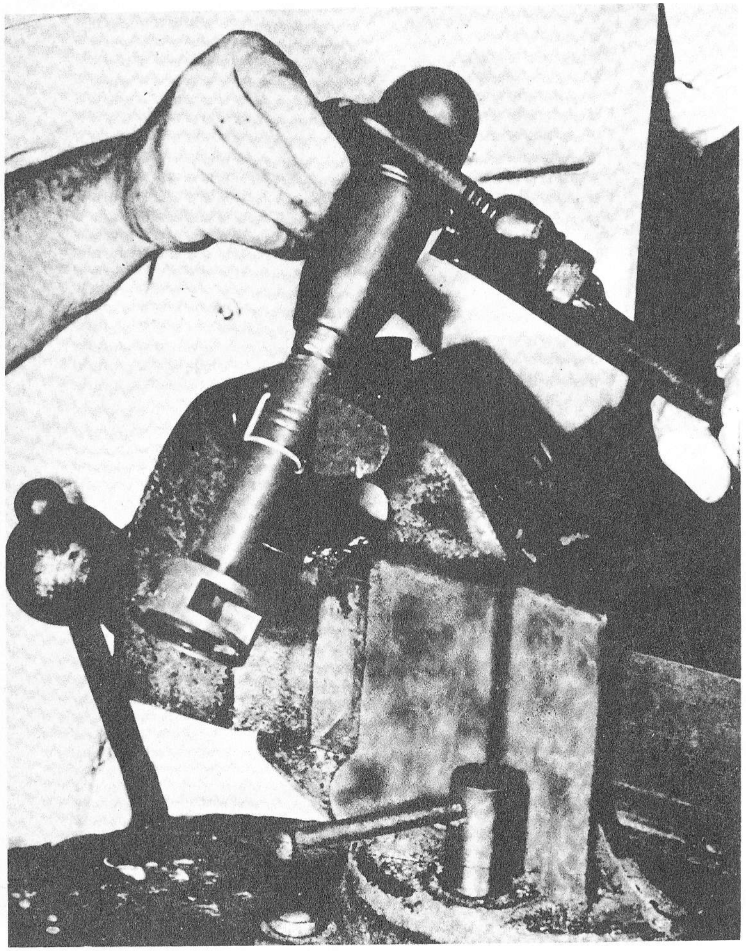


Figure 98 B

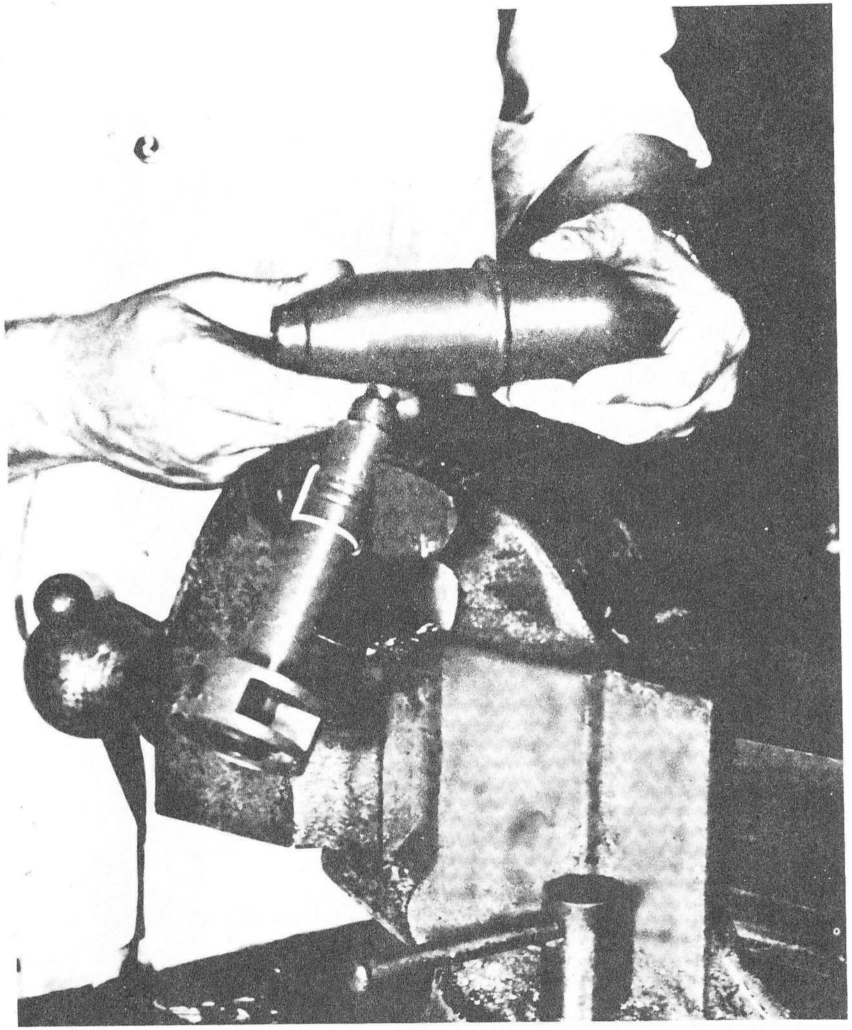


Figure 98 C

The ogive (curve of the head) of this projectile assures proper standoff. (This is true of all projectiles.) It may be necessary to fashion support legs.

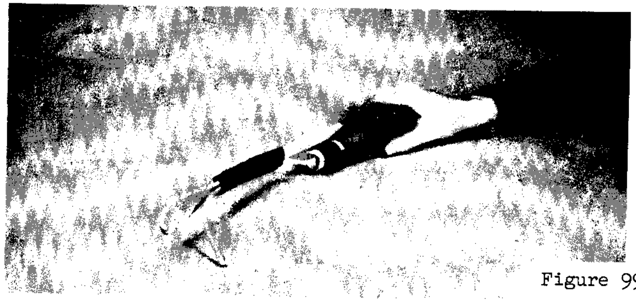


Figure 99

2. Rocket, HE, AT, 2.36-inch, M6A5 (See Fig. 100.)

a. Characteristics

Container	Sheet steel
Liner material	Copper
Liner shape	Cone
Liner angle	42°
Liner thickness	.059 inches
Explosive	$\frac{1}{2}$ pound of 50-50 Pentolite.

The M6A5 HE, AT rocket will penetrate 4 to 5 inches of armor plate or 6-10 inches of mild steel.

b. Disassembly (See Fig. 101.)

(1) Wrap tape around safety band to prevent accidental removal of safety pin.

(2) Lock with a vise or pipe wrench.

(3) File or saw through the peen mark that locks the motor tube to the head.

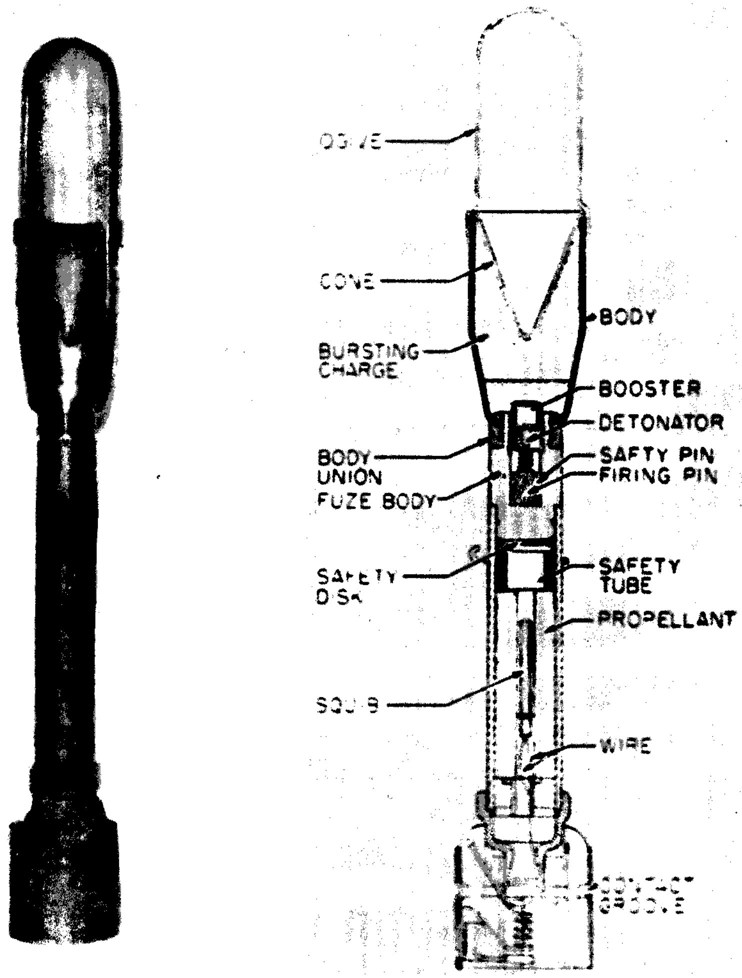


Figure 100

(4) Remove the head component by unscrewing it in a counterclockwise direction.

This is as far as disassembly need proceed. Before the booster and detonator assembly is disposed of, the fin assembly should be removed to facilitate the removal of the squib and propellant, both of which may be burned in some open area.

c. Priming

(Same as with the rifle grenade.)

3. Rocket, HE, AT, 3.5-inch M28A2 (See Fig. 102.)

a. Characteristics

Container	Steel tubing
Liner material	Copper
Liner shape	Cone
Liner angle	42°
Liner thickness	.093 inches
Explosive	1.82 pounds of Composition B.

The M28A2 HE, AT Rocket will penetrate 7 to 8 inches of armor plate or 8 to 12 inches of mild steel.

b. Disassembly (See Fig. 103.)

(1) Although this rocket has a bore safety feature, it is recommended that tape be wrapped about the safety band to prevent accidental removal of the safety pin.

(2) File or saw through the head peen mark which locks the fuse and motor tube to the head.

(3) Lock the head with a pipe wrench or vise.

(4) Remove the fuse and motor tube by unscrewing them in a counterclockwise direction. Place the second wrench just behind the safety band, as shown. The detonator

Figure 101 A

Figure 101 B

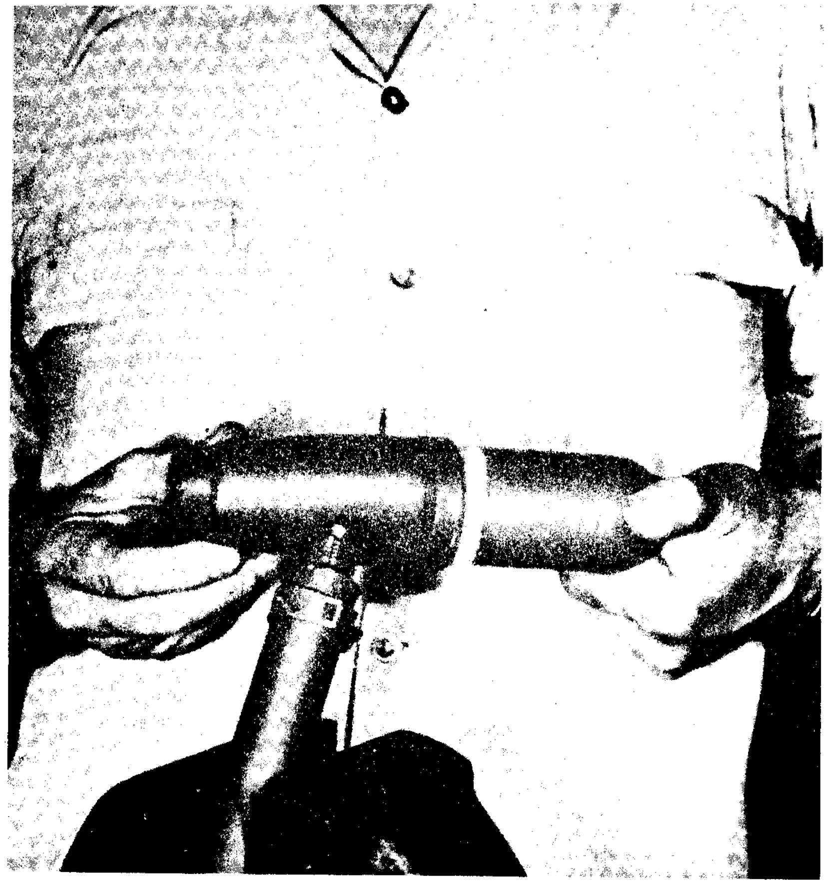


Figure 101 C

Figure 101 D

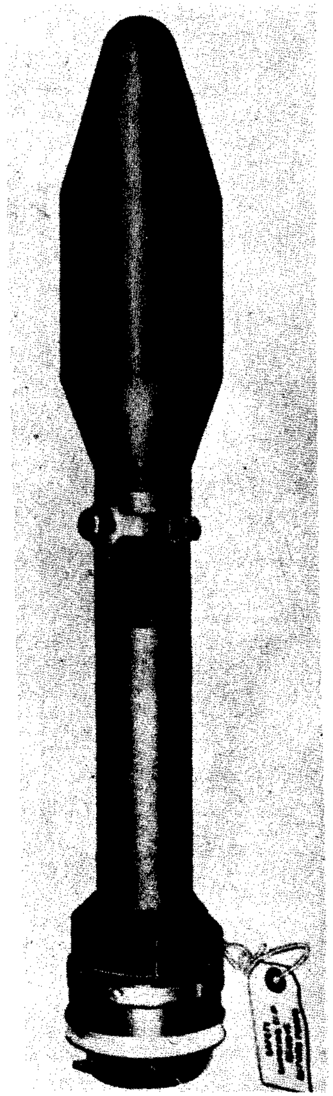


Figure 102 A

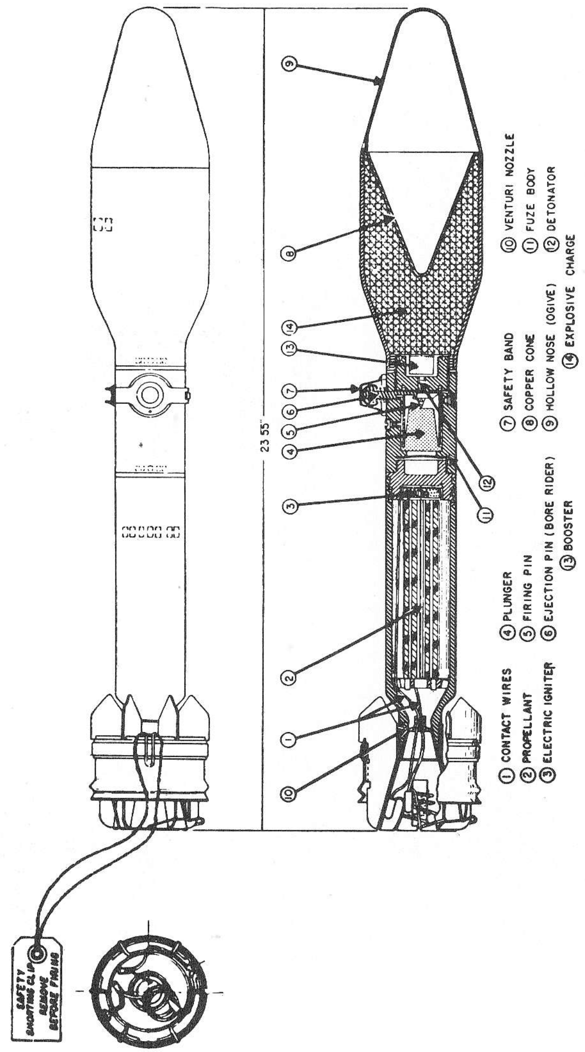


Figure 102 B

may remain connected to the head or it may unscrew as part of the motor tube, depending on which particular thread is tighter.

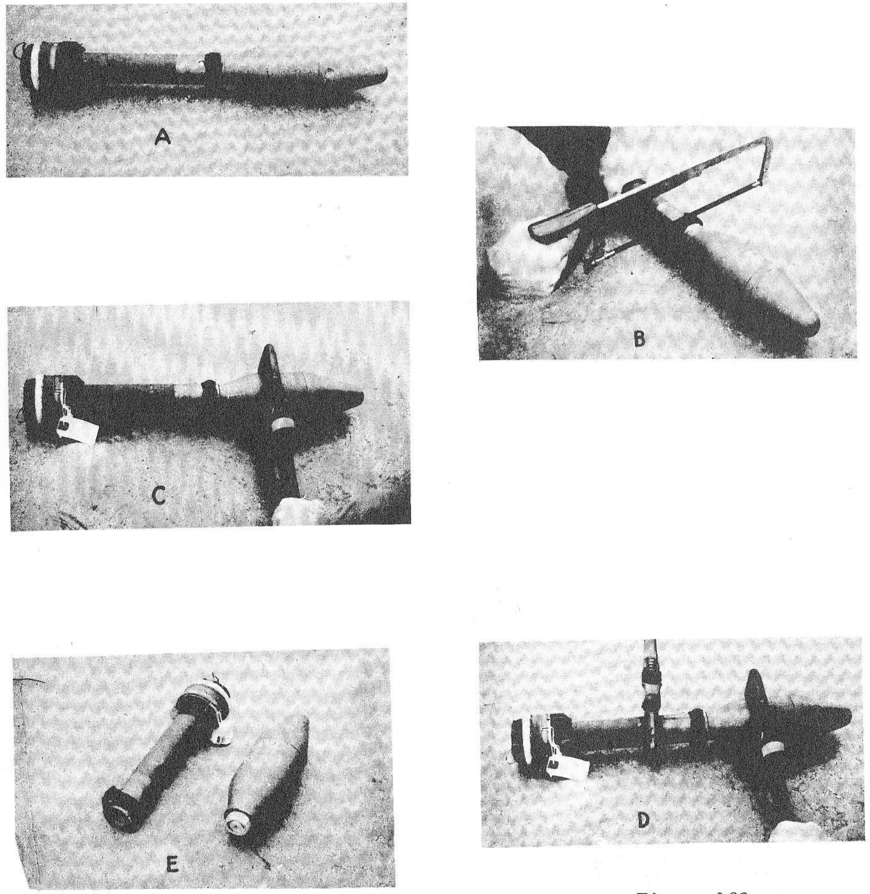


Figure 103

c. Priming

The detonator may or may not separate from the head. In either case, prime the charge as described for the rifle grenade. (The propellant should be disposed of as in the case of the 2.36-inch rocket.)

4. Artillery Projectiles

Artillery projectiles should not be disassembled unless the person performing the operation is well acquainted with the procedure. Otherwise, test shots using "doughnut" primers arranged about the shell-casing crimp should be used (see Fig. 104). This technique may be used on the grenade and rocket projectiles previously discussed when tools necessary for disassembly are not available.

5. Priming High-Explosive Bombs and Projectiles with Shaped Charges

All H.E. bombs and projectiles may be primed with very small (M9,AT Grenade-type) shaped charges. These should be placed as is shown in Fig. 105.

F. Unorthodox Firing of Shaped Charges (See Fig. 106)

Experience has shown that shaped-charge jets retain penetration velocity at distances far beyond their normal standoff. This is particularly true of charges lined with metal. Experiments conducted with the shaped charges taken from various projectiles show that jets will penetrate steel plates from distances of several feet. The depth of penetration is, of course, dependent on the standoff. This is considered quite important in that targets such as ships, trains, etc., carrying cargoes of munitions, may be attacked without the saboteur's having to lay a hand on the target. Success in attacking munition ships, trains, and underground storage bunkers will depend on the existence of considerable residual jet energy, -- i.e., after the jet has penetrated the initial air gap or standoff and the skin or wall of the ship, boxcar, or bunker, it must still be capable of traveling through several feet of air gap and penetrating the casing of a high-explosive projectile with sufficient velocity to detonate the projectile. The difficulty of aiming the highly directional jet is somewhat overcome by detonating a battery of spaced charges simultaneously.

At this time, there are no definite figures pertaining to the extent of penetration of a particular charge from various standoff distances. Therefore, it is necessary that test shots be conducted before this technique is used operationally.

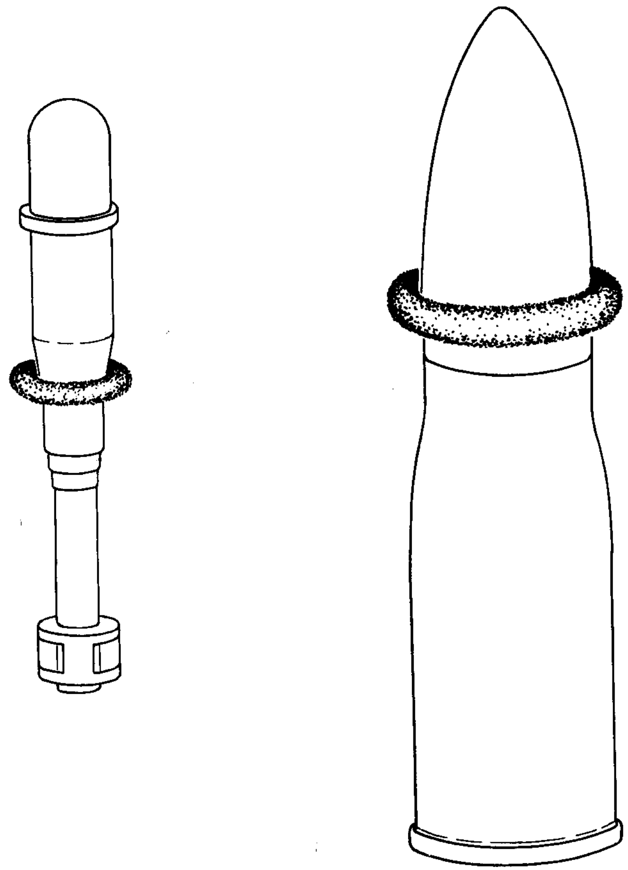


Figure 104

Method of Priming Shaped Projectiles with Doughnut Charges

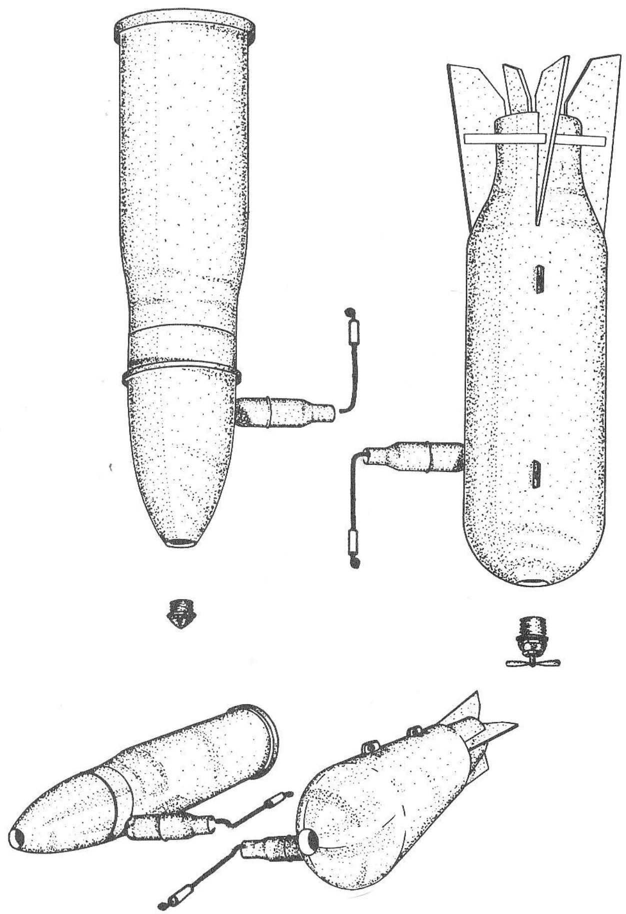


Figure 105

Method of Priming Artillery Projectiles
and Aerial Bombs with Shaped Charge

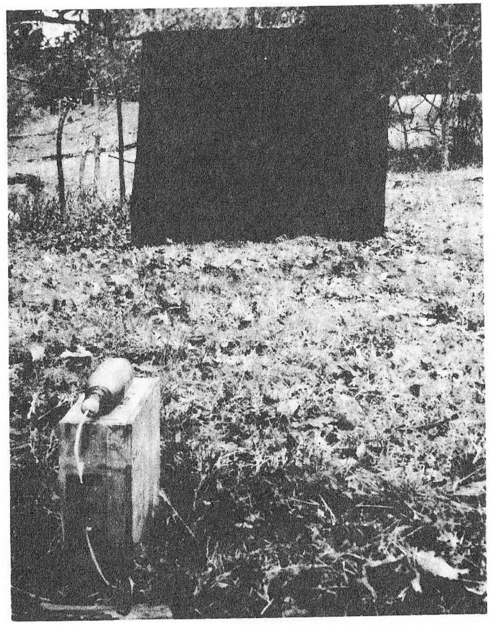


Figure 106

G. Improvised Shaped Charges

Any symmetrical glass utensil will serve as a suitable cavity liner for improvised shaped charges. Generally speaking, the more conical the shape the better the resulting penetration; therefore, an inverted custard cup would be better than an inverted water glass, and a wine bottle with a cavity base better than the inverted custard cup. Fig. 107 shows how a suitable shaped charge may be fashioned from simple materials.

1. The bottle is divided by burning an oil- or kerosene-soaked string tied around the bottle at the desired point of fracture. When burning has continued for a minute or two, the bottle is plunged into cold water.

2. Warmed C-3 or C-4 is packed into the bottle and carefully tamped to remove all air pockets around the cavity base. The amount of explosive used is governed by the diameter of the cavity. For best results, the explosive should be between two and three cavity diameters deep.

3. To conserve explosive, the top of the charge should be dome shaped; however, if the charge is to be kept for more than a day, or if the temperature is unusually high, a flat-topped charge should be used.

4. A priming knot should be seated within the explosive. To make sure it remains centered, a mast may be taped to the container and the detonating cord priming lead secured to it.

5. If time permits, the top of the charge may be coated with a viscous, quick-drying tar. This will add stability to the charge and prevent the priming knot from working loose.

6. For improvised charges, it has been found that standoff equal to .75 of the charge diameter is the most effective. Standoff legs may be nails, sticks, etc., taped to the container.

Unlined charges are generally considered inefficient, since the symmetry of the cavity is difficult to fashion and more difficult to maintain. The relative efficiency of unlined shaped charges versus conventional charges of the same explosive should be ascertained by test shots.

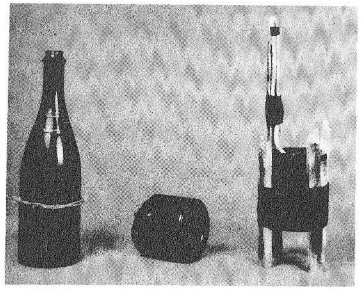


Figure 107

H. Linear Charges

A linear shaped charge may be described as an explosive mass having a V- or crescent-shaped groove in one side, along its longitudinal axis. Its purpose is to cut its length through a target with less explosive than that required by a conventional charge. While the theory of the linear charge is similar to that of the cylindrical charge, there is

at least one important difference, namely that the linear charge has only two sides so there is no jet, or at least not one that is comparable to that of the cylindrical charge. So, although there is an increase in the velocity of the gases within the shape -- with a corresponding efficiency increase -- a linear charge of a particular weight is not capable of the same penetration as a cylindrical charge of the same weight.

1. Improvised Linear Charges (See Fig. 108.)

Since linear charges are not issued, it will be up to the individual to provide himself with a suitable homemade charge.

The linear charge should have an apex angle of from 60° to 80°.

Standoff should be between .5 to .75 of the charge width.

Copper or zinc sheeting may be cut and bent to serve as lining. Window glass also gives suitable results.

Charges should be packed in a wooden box if they are to be subjected to field handling.

The linear charge is primed by placing a detonating cord knot in the priming dome, which is located at the midpoint of the top of the charge.

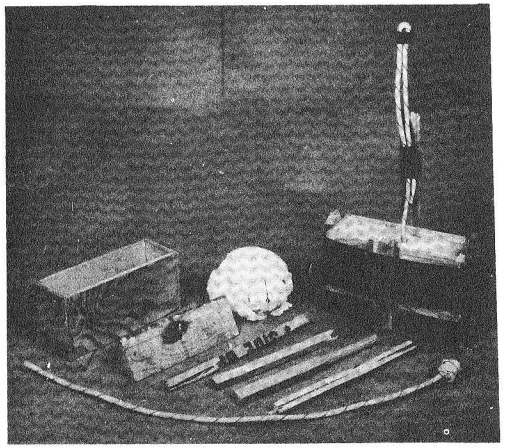


Figure 108

CHAPTER II. SPECIAL FIRING SYSTEMS

SECTION 1. INTRODUCTION

A. General

The electric and nonelectric firing systems discussed in Chapter I. are basic in both commercial and military demolitions. While these simple assemblies are suitable for the majority of sabotage and guerrilla-warfare requirements, there are other types of firing systems which serve specific purposes in a more satisfactory manner. This chapter covers many of these special types of firing systems and their application in paramilitary operations.

B. Firing System

A firing system consists of those items of equipment associated with an explosive or incendiary charge which provide for triggering action, delay, and the final detonation or ignition of the charge.

C. Special Firing Systems and Fuses

The principal component of the special firing system is the fuse (firing device). A fuse is a device which activates the spark or flame necessary to ignite a delay train or to fire an incendiary or explosive charge. There are literally hundreds of such devices available throughout the world. This chapter is compilation of representative fuses and their uses, rather than a complete catalog of procurable items. The knowledge of why and how the different fuses operate may help the saboteur to select or build the type of device most suitable to his needs.

Normally, fuses function by mechanical, electrical, or chemical energy or a combination of the three. Fuses generally take their names from the force that triggers them (pull, pressure, etc.). In many cases the fuse may include a time-delay feature, as in a chemical device where a complete reaction may require several hours.

Besides the fuse, a firing system is likely to consist of one or more of the following: blasting cap, safety fuse, various chemicals, etc.

D. Principles of Fuse Operation

Although fuses differ in design and operation, the actions that control their performance are similar. These are:

All fuses may be handled safely until they are armed.

All fuses are tripped, triggered, or set off by some predictable or controllable force.

All fuses function to produce a spark of flame. This is referred to as the <u>initiating action.</u>

1. <u>Arming and Disarming Action</u>

   Arming action consists of those manipulations needed to ready a fuse for firing. This includes the removal of the safety pin and perhaps the adjustment of a switch, motor, etc. with which a fuse may be equipped. For those few fuses which are not equipped with safety pins, arming consists merely of placing the fuse for firing.

   Replacement of the safety pin or otherwise rendering a fuse inoperable is called disarming.

2. <u>Triggering Action</u>

   Triggering action is that action which causes a fuse to function. It is analogous to the triggering action of a firearm in that a train of events is set in motion when the trigger is actuated. While the triggering action is mechanical for all firearms, this is not so for all fuses. The majority of the fuses described in this Handbook are mechanically triggered, but there are others which rely on electronics, sound, light, etc.

   Triggering action should not be confused with arming action. Fuses are often armed and triggered at about the same time, e.g., when the mechanical clockwork of a fuse is set in motion before the safety pin is withdrawn, or vice versa. The winding and setting of the clockwork and the removal of associated safety pins constitutes the arming action. Setting the clockwork in motion is the triggering action.

3. <u>Initiating Action</u>

   Initiating action is that action which takes place within the fuse to cause firing (the production of a spark or the triggering of a second fuse). Normally, this action is produced by mechanical, electrical, or chemical energy, or a combination of them. Initiating action is either instantaneous or delayed (see Fig. 109). Instantaneous action is accomplished in the fraction of a second following triggering. Delay action takes place throughout the predictable time lapse that occurs between triggering and firing.

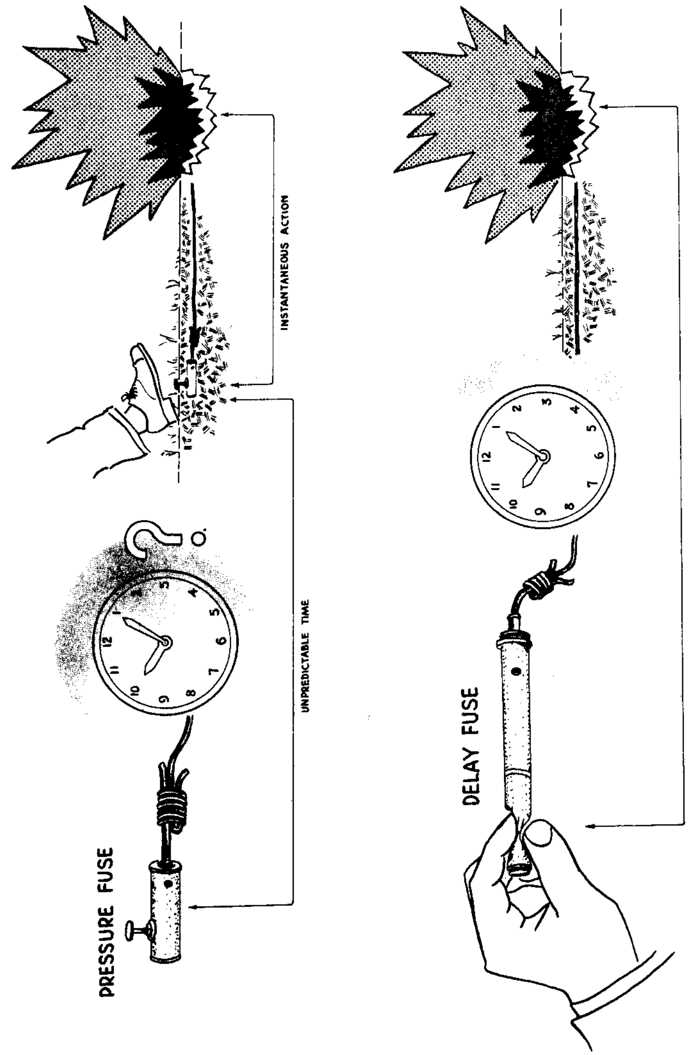


Figure 109

E. Categories of Fuses

All fuses discussed in this Handbook are classified in one of the following categories: (1) general purpose fuses, (2) special purpose fuses, and (3) homemade fuses.

1. General Purpose Fuses

General purpose fuses are those small firing devices that are available in quantity and which may be used in a number of different ways. All of the mechanical fuses that are generally referred to as booby-trap switches fall within this category, as do the small delay devices issued to military and paramilitary forces (see Section 2).

2. Special Purpose Fuses

Special purpose fuses are those fuses which are designed especially for use in one type of operation, e.g., train derailments, attacks on aircraft, etc. (see Section 3).

3. Homemade Fuses

Homemade fuses are those devices which are fashioned in the field by field personnel. In the majority of cases it would be technically correct to say that the homemade device is a special purpose fuse, in that it is conceived and constructed to suit a definite operational circumstance (see Section 4).

SECTION 2. GENERAL PURPOSE FUSES

A. General

The majority of the fuses described in this Section were designed for the use of military forces as firing devices for booby traps and antipersonnel mines. (The uses to which a saboteur may put a particular fuse and the techniques associated with those uses are discussed following the description of the device.)

Because paramilitary forces are sometimes forced to disarm, or otherwise render harmless, booby traps and AP (antipersonnel) mines (to effect penetration of target areas or to acquire mines or explosive charges for their own operations), a knowledge of why and how certain of the booby traps and mines operate may be helpful in neutralizing others not discussed in this Handbook.

(Note: Although the items described herein are generally representative of the types of fuses available throughout the world, it must never be assumed that a knowledge of the few fuses presented in this Handbook qualifies an individual to attempt to disarm a strange device.)

General purpose fuses are classified in the following order: (1) booby trap fuses, (2) delay fuses, and (3) miscellaneous fuses.

B. Booby Trap Fuses

1. Pull Fuses

Pull fuses are designed to fire when a mechanical pull is exerted on their triggering mechanism.

a. Pull Fuse M1 (Fig. 110)

(1) Uses:

(a) Pull-type booby traps.

(b) Lanyard firing device.

(c) Fuse lighter.

(d) Miscellaneous.

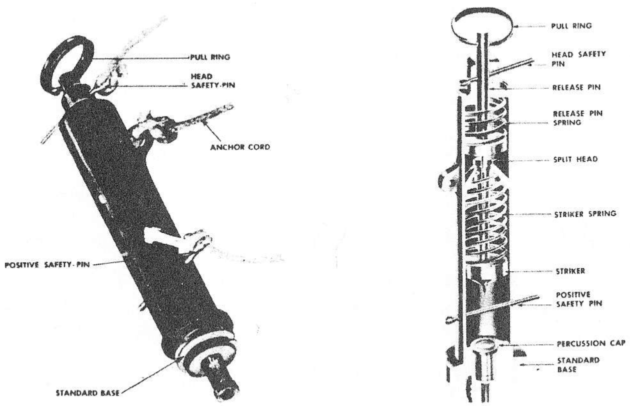


Figure 110

(2) Functioning:

(a) A 3- to 5-pound pull on the pull ring compresses the release pin spring and removes the release pin from the split head of the striker.

(b) This permits the split head of the striker to slip through the collar.

(c) The striker is driven onto the percussion cap by the striker spring.

(3) Testing:

Fuses should be tested when their design permits re-cocking.

(a) Remove the standard base and invert it. Insert the crimp snout so that it faces the firing pin. Hold the base in this position.

(b) Remove the safety pins.

(c) Pull outward on the pull ring. The striker should strike the base sharply.

(d) Re-cock the fuse by pushing the striker back into the case with an unsharpened pencil or similar instrument until the release pin is re-seated.

(e) Insert safety pins and screw in base.

(4) Installation:

(a) Pull-type Booby-Trap Firing System

1. Affix the fuse to a stationary object by tying it to the stationary object with a cord or wire which is passed through the anchor recess.

2. Attach a trip wire to the pull ring and extend it to a distant anchor point. (The trip wire should be about a foot above the ground.)

3. Do not draw the trip wire so tight that it causes the head safety pin to bind.

(b) Lanyard-type Firing System (Fig. 111)

1. Affix the fuse to a stationary object.

2. Attach the wire lanyard to the pull ring and extend it to the covered position from where it will be pulled.

3. It is advisable to substitute a small nail equipped with a lanyard for the positive safety pin.

(c) Fuse Lighter (Fig. 112)

1. Split the end of a length of safety fuse through the powder train, as is shown in Fig. 112.

2. Place a matchhead at the apex of the split, being careful not to disturb too much of the powder.

3. Position the split fuse so that the end of the crimp snout rests against the matchhead, as shown.

4. Tightly bind the halves of the fuse to the snout with a rubber band or piece of cord.

(d) Miscellaneous Uses (Fig. 113)

With a few nails and simple tools, this device can be arranged to function as a pull-release or pressure switch.

(Note: Whenever possible, dual firing systems should be used.)

(5) Priming:

(a) Remove the base and strip the waterproofing material from the crimp snout.

(b) Insert the snout into the open end of the blasting cap and crimp.

(c) Attach the base to the fuse.

(d) Insert the blasting cap in the charge or make a connection with the detonating cord.

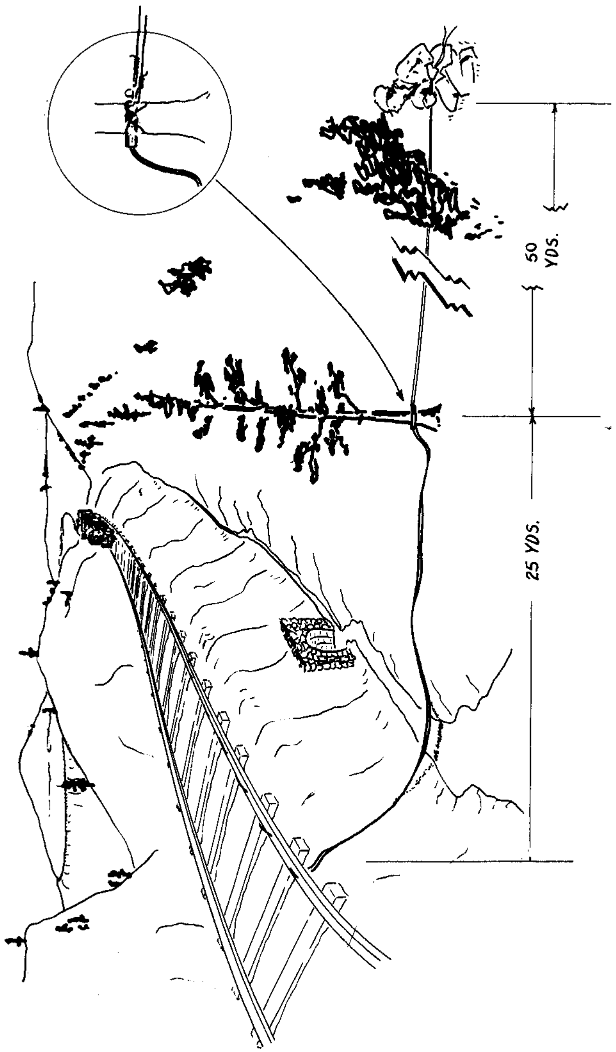


Figure 111

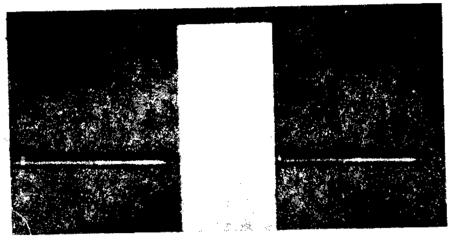


Figure 112

(Note: The standard base is threaded to fit the blasting cap wells of several standard explosive blocks, as well as of grenades.)

(6) Arming:

(a) Remove the head safety pin. If it does not pull out easily, the tension of the trip wire should be relaxed. If this is not the trouble, remove the standard base and re-test the device.

(b) Remove the positive safety pin. If this does not pull out easily, the head safety pin should be replaced and the device re-tested. CAUTION: Under no circumstances should a sticking positive safety pin be pulled out; the chances are that the striker has fallen and is binding the safety pin. Removal of the pin in this case will normally cause firing.

(7) Disarming:

(a) Insert both safety pins. It is advisable to replace the positive safety pin first. Small nails are ideal for disarming.

(b) Disconnect the trip wires, after both ends have been examined for additional traps.

(c) Separate the fuse and the charge.

(d) Remove the standard base and blasting cap together. (Note: Do not attempt to remove the cap from the base.)

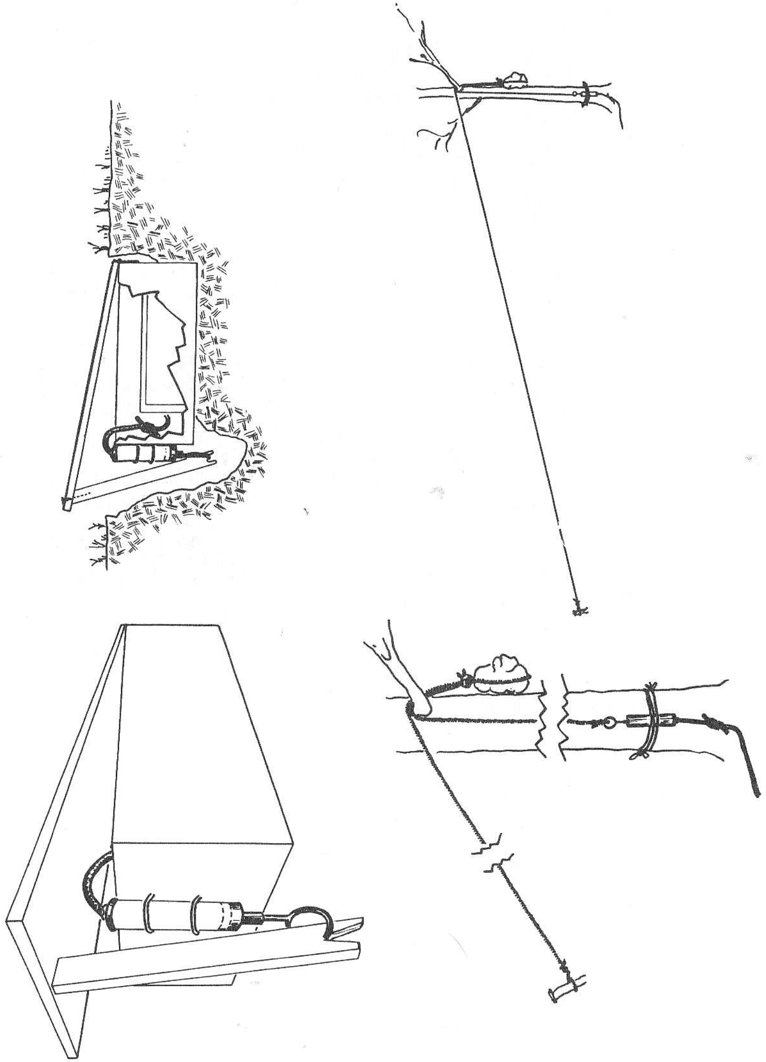


Figure 113

b. British Pull Fuse No. 4 (Fig. 114)

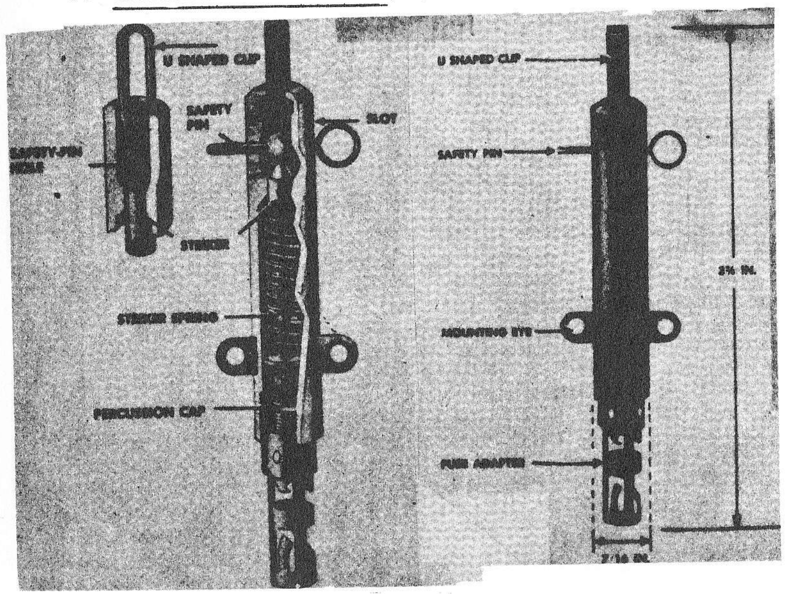


Figure 114

(1) Uses:

(Same as for Pull Fuse M1.)

(2) Functioning:

(a) A 6- to 8-pound pull withdraws the U-clip from the ball end of the striker.

(b) The compressed striker spring drives the striker onto the percussion cap.

(3) Testing:

(a) Remove the base. (Notice that this base is equipped with a spring snout.)

(b) Exert enough tension on the U-clip to center the safety pin in the vertical slot. Remove the safety pin.

(c) Place the striker end of the device on a board or other flat surface and pull outward on the U-clip. The firing pin should strike the board sharply.

(d) Re-cock the fuse by pushing the striker into the case as far as it will go. The ball end of the striker will protrude from the opposite end of the case.

(e) Align the safety pin recess in the ball end of the striker with the safety pin slots of the case. Fit the U-clip over the ball end of the striker.

(f) Relax tension on the striker and allow it to come forward about one-quarter inch. This will align the safety pin slots with the recess in the ball end of the striker.

(g) Insert the safety pin and replace the base.

(4) Installation:

(Same as for Pull Fuse M1.)

(Note: The spring snout is an excellent receptacle for safety fuse; the spring prongs dig into the fuse covering and thus prevent the fuse from being pulled out of the firing device.)

(5) Priming:

The procedure for priming this device is in general identical with that for the Pull Fuse M1. An exception is the blasting cap connection. With this device, the open end of a blasting cap is inserted into the spring snout and pushed to its proper seating position. It is unnecessary to tape or otherwise bind snout and cap together. The tension exerted by the spring prongs of the snout is usually sufficient to hold the two together. (Note: This connection is not water-resistant.)

(6) Arming:

(Same as for Pull Fuse M1.)

(Note: Too much or too little tension on the U-clip will prevent the easy removal of the safety pin.)

CAUTION: Never force a jammed safety pin.

(7) Disarming:

(a) Replace the safety pin.

(b) Proceed as described for the Pull Fuse M1. (Note: The blasting cap can be removed from the spring snout.)

c. Russian Pull Fuse MUV (Fig. 115)

(Note: This fuse is similar to the German ZZ-42 fuse, the Italian 1-pound antipersonnel mine fuse, and the Finnish pull fuse.)

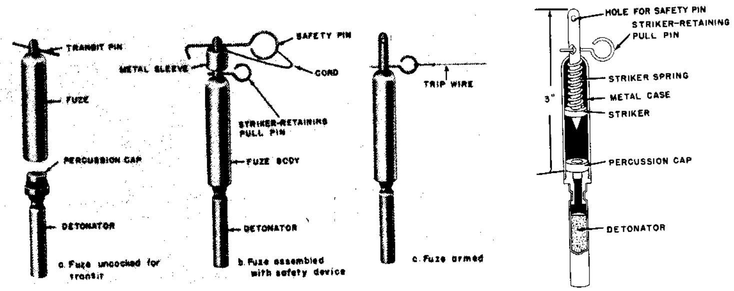


Figure 115

(1) Uses:

(Same as for Pull Fuse M1.)

(2) Functioning:

A 1- to 2-pound pull withdraws the pull pin, allowing the compressed striker spring to drive the striker onto a percussion cap.

(3) Testing:

The fuse mechanism is shipped separately from the cap and detonator assembly. Do not handle the cap and detonator assembly while making this test.

(a) Compress the striker spring by exerting an axial pull on the transit pin. Maintain the tension and insert the pull pin in the lower pin recess of the striker rod. Relax the tension.

(b) Place the fuse on a board or similar flat surface so that the striker rod points upward. Pull the pull pin from its recess. The striker should strike the board sharply.

(4) Installation:

(Same as for Pull Fuse M1.)

(Note: This fuse cannot be used to ignite safety fuse.)

(5) Priming:

(a) Repeat step (a) of the test procedure.

(b) Remove the transit pin and place the metal sleeve or spacer on the striker rod. Insert the safety pin into the upper pin recess.

(c) Screw the cap and detonator assembly into the base of the fuse.

(d) Insert the detonator in an explosive charge or connect it to detonating cord.

(6) Arming:

(a) Remove the safety pin, after checking to see that the pull pin is well seated within its recess and that the trip wire is loose.

(b) Remove the metal sleeve.

(7) Disarming:

(a) After associated trip wires have been inspected for additional booby traps and found to be clear, they may be cut.

(Note: This fuse may be set with a taut trip wire attached to the outer pin recess and with the pull pin removed. When set this way, the fuse will function when the attached trip wire is cut. In this case, insert a safety pin in the pull pin recess before cutting the trip wire.)

(b) Separate the fuse from the explosive charge and unscrew the cap and detonator assembly.

d. Japanese Friction Fuse Lighter No. 2 (Fig. 116)

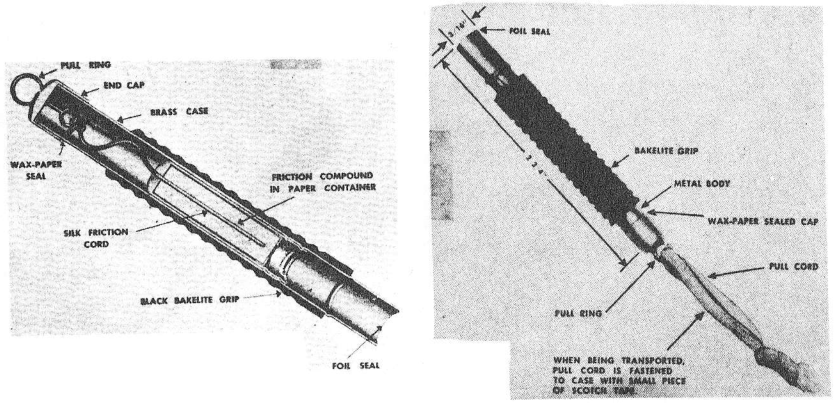


Figure 116

The friction ignition principle is used by many countries. Generally speaking, this type of mechanism is more susceptible to moisture contamination than percussion-type fuses.

(1) Uses:

(Same as for Pull Fuse M1.)

(2) Functioning:

(a) A pull of approximately 10 pounds on the pull ring detaches the end cap and draws the coated silk cord through a friction compound.

(b) This produces a shower of sparks that will initiate safety fuse and blasting caps.

(3) Testing:

(a) This is a one-time fuse and therefore no test other than inspection can be made.

(4) Installation:

(Same as for Pull Fuse M1.)

(5) Priming:

(a) Insert the blasting cap or safety fuse in the base receptacle.

(b) Connect to the main charge.

(6) Arming:

(a) Since there are no safety pins to remove, arming consists of placing the device in a firing position.

(7) Disarming:

(a) If the end cap is detached from the case or if the waxed paper seal has been broken, the cap should be fully seated and secured in place with a turn of tape.

(b) Disconnect associated trip wires after they have been found clear of other devices.

(c) Remove the fuse from the main charge.

2. Pressure Fuses.

Pressure fuses are designed to fire when pressure is exerted on their triggering mechanisms.

a. Pressure Fuse M1A1 (Fig. 117)

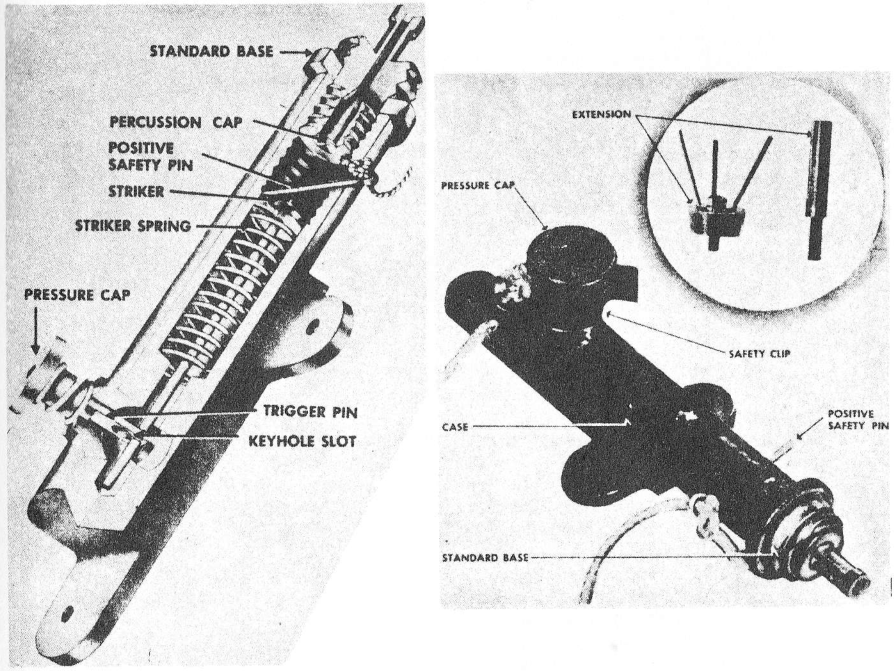


Figure 117

(1) Uses:

(a) Booby traps.

(b) Fuse lighters.

(c) Improvised mines.

(2) Functioning:

(a) Pressure of 20 pounds or more on the pressure cap causes compression of the trigger spring as the trigger pin is forced into the case.

(b) The striker is released as soon as the narrow portion of the trigger pin's keyhole slot disengages the striker-rod groove.

(c) The striker is driven forward onto the percussion cap by the striker spring.

(3) Testing:

(a) Remove the standard base and place as outlined in the Pull Fuse M1 test.

(b) Remove the safety clip and the safety pin.

(c) Apply pressure to the pressure cap. The striker should strike the base sharply.

(d) To re-cock, push the striker into the case with an unsharpened pencil or similar tool. The trigger pin must be depressed at the same time, so that the striker rod may pass through the eye of the keyhole slot.

(e) Relax pressure on the pressure cap, to permit the narrow portion of the keyhole slot to engage the groove in the striker rod.

(f) Replace the safety clip and pin.

(4) Installation:

(a) Booby trap and improvised antivehicle mines.

(b) Fuse lighters.

(c) Improvised mines for derailment of trains (see Fig. 118). This technique should be tested with inert but operable fuses at the actual derailment site. This should be done to ascertain that, when a train passes, the track settles sufficiently to fire the device.

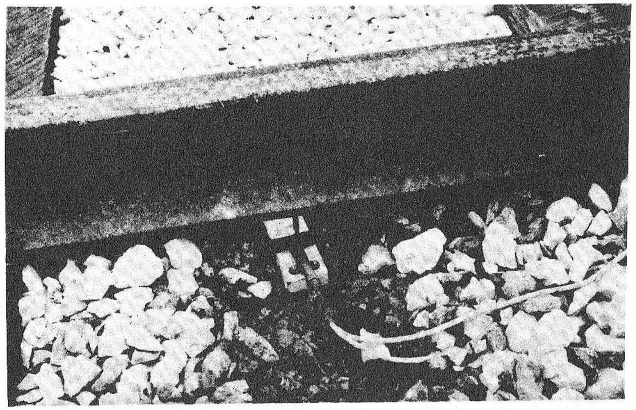


Figure 118

(5) Priming:

(a) Secure the fuse to a wooden board that will assure a firm base.

(b) Equip the base with a blasting cap and connect the primed fuse to the main charge.

(6) Arming:

(a) If the extension rod is being used, adjust it to fit snugly between the pressure cap and the other object being used, then back it off one-quarter turn.

(b) Remove the safety clip. If the clip does not pull off easily, do not force it. Instead, remove the standard base and check the mechanism.

(c) Remove the safety pin. If the pin does not pull out easily, do not force it. Instead, replace the safety clip and repeat the test procedure.

(7) Disarming:

(a) Replace the safety pin and clip.

b. British Pressure Fuse No. 5 (Fig. 119)

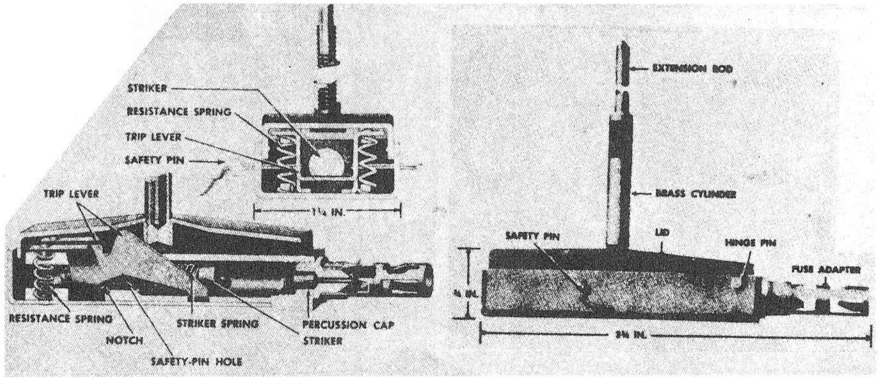


Figure 119

(1) Uses:

(Same as for Pressure Fuse M1A1.)

(2) Functioning:

(a) Pressure of 21 to 60 pounds on the lid causes depression of the trip lever, which is supported by two resistance springs.

(b) When the trip lever disengages the notch in the striker rod, the striker is driven against the percussion cap by the striker spring.

(3) Testing:

(a) Remove the base and place the open end of the fuse against a board or similar flat surface.

(b) Remove the safety pin.

(c) Apply pressure to the lid. The striker should strike the board sharply.

(d) To re-cock, push the striker (notch down) into the device with an unsharpened pencil or similar tool. Depress the lid at the same time, so that the trip lever is in position to engage the striker notch. Relax the pressure on the lid and allow the trip lever to seat itself in the notch.

(e) Replace the safety pin and base.

(4) Installation:

(Same as for Pressure Fuse M1A1.)

(5) Priming:

(a) Prime in the manner outlined for Pull Fuse No. 4.

(6) Arming:

(Same as for Pressure Fuse M1A1.)

(7) Disarming:

(a) Insert the safety pin and remove the base.

c. German Pressure Fuse S. Mi. Z. 35 (Fig. 120)

(1) Uses:

(Same as for Pressure Fuse M1A1.)

(2) Functioning:

(a) Pressure of 8 to 10 pounds on the prongs overcomes the resistance of the outer spring and depresses the plunger.

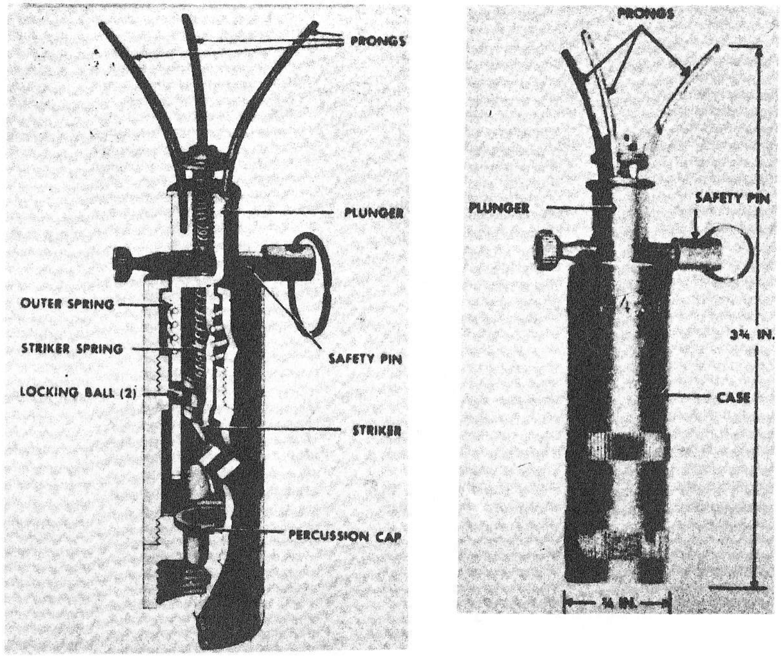


Figure 120

(b) This permits the two locking balls to "pop outward" after having been depressed to a point below the collar.

(c) This frees the striker, which is driven onto the percussion cap by the striker spring.

(3) Testing:

Disassembly of this fuse is extremely difficult without special tools. It should, therefore, be considered a one-time fuse. Testing should consist of inspections to see that the safety pin is not unduly tight and that the percussion cap has not been fired.

(4) Installation:

(Same as for Pressure Fuse M1A1.)

(5) Priming:

The base of this fuse is threaded to facilitate firm attachment to the "S" Mine (the "Bounding Mine"), or to various priming adapters.

(a) To prime with a conventional blasting cap, it is first necessary to improvise an adapter from wood, cork, plastic, etc. The adapter should be so made that the cap is positioned within one-half inch of the percussion cap. Also, the adapter should hold the cap firmly.

(b) The primed fuse should be connected to the main charge.

(6) Arming:

Remove the safety pin. If the pin does not pull out easily, do not force it. Remove the blasting cap and repeat Testing.

(7) Disarming:

Insert the safety pin and remove the blasting cap.

d. Russian Pressure Fuse MV-5 (Fig. 121)

Pressure Fuze, MV-5

RECOGNITION FEATURES

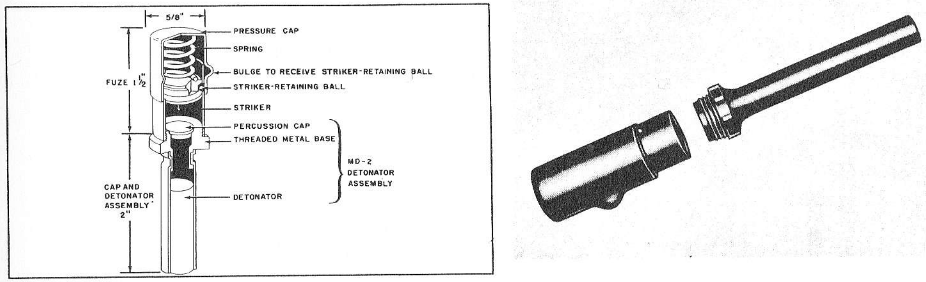


Figure 121

(1) Uses:

This fuse was designed primarily for use in antitank and antipersonnel mines.

(2) Functioning:

(a) Pressure of 22 to 44 pounds on the pressure cap depresses the cap, overcoming the tension of the pressure-cap spring.

(b) This aligns the retaining-ball recess of the striker with the pressure-cap bulge, and the ball is forced outward into the bulge.

(c) The striker is driven onto the percussion cap by the pressure cap spring.

(3) Testing:

Since information relevant to the firing and re-cocking of this device for test purposes is not available, testing should consist of an examination of the device to see that the striker has not fallen and that it does not fall when subjected to the shocks of handling. The cap and detonator assembly, which is packaged separately, should never be handled while the fuse is being examined.

(4) Installation:

With the exception of fuse lighting, this fuse will perform the same functions as other types of pressure fuses (see Pressure Fuse, M1A1).

(5) Priming:

This fuse has no safety device. For this reason, the cap and detonator assembly should not be connected to the fuse until ready for use. Priming consists of attaching the assembled fuse to the main charge.

(6) Arming:

Since the device is not equipped with a safety pin, arming consists of placing the fused charge in a firing position.

(7) Disarming:

Without exerting any pressure on the pressure cap, unscrew and remove the cap and detonator assembly.

3. Pressure-Release Fuses

Pressure-release fuses are designed to fire upon relaxation of a restraining pressure.

a. Pressure-Release Fuse M5 (Fig. 122)

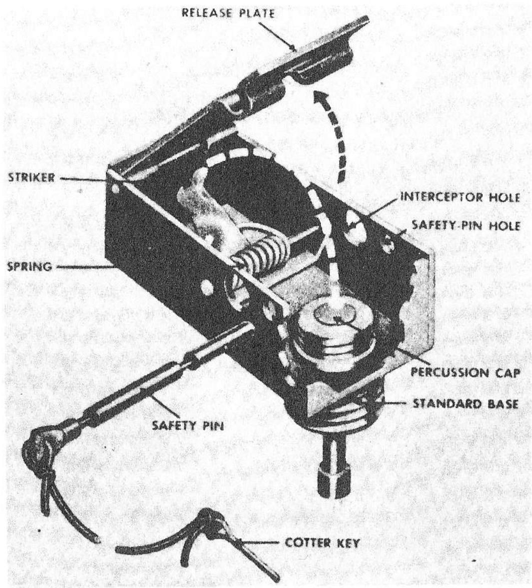


Figure 122

(1) Uses:

(a) Booby traps.

(b) Fuse lighter.

(c) Lanyard-operated firing systems.

(2) Functioning:

(a) When a restraining load of at least 5 pounds is displaced, the release plate is forced upward by the spring-driven striker.

(b) The striker rotates about the striker pin and fires the percussion cap.

(3) Testing:

(a) Remove standard base and set it aside.

(b) Place the device on a flat surface so that the release plate is down. Grasp the sides of the device and exert a downward pressure.

(c) Retain pressure and remove safety pin.

(d) Relax pressure. The striker should strike the fuse case sharply.

(e) To re-cock, place the device with the release plate up. With a nail or similar instrument, rotate the striker toward the opposite end of the case. Hold the striker in the cocked position until the release plate is able to restrain striker movement. Withdraw the nail and close the release plate. Insert the safety pin and cotter key. Re-connect the base to the case.

(4) Installation:

(a) Booby traps (Fig. 123).

(b) Fuse lighter (see Pull Fuse M1).

(c) Lanyard-operated firing device (Fig. 123).

(5) Priming:

Equip the base with a blasting cap and connect the primed fuse to the main charge.

(6) Arming:

(Note: Make a test with the base removed, in order to ensure that the pressure load or booby trap bait is sufficient to prevent operation.)

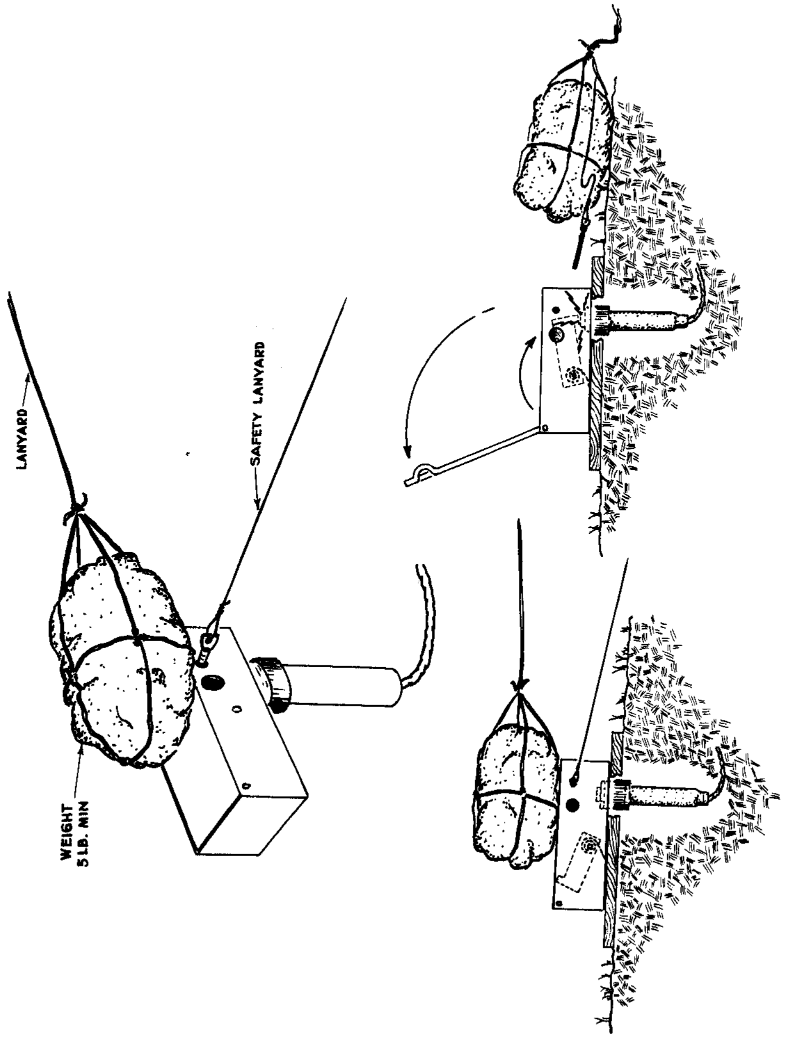


Figure 123

(a) Remove the cotter key from its recess in the safety pin.

(b) Place pressure load on the fused charge. Make sure that the weight rests directly on the fuse.

(c) Pull out the safety pin. It should come out easily; if difficulty is encountered, do not force it. Instead, slip a nail through the interceptor holes and then restore the safety pin and remove the restraining load. After the base has been removed, the device should be re-tested.

(<u>Note</u>: The additional safety precaution of having a nail through the interceptor holes throughout the arming procedure is sometimes considered advantageous.)

(7) Disarming:

(a) Without disturbing the restraining load, place a nail through the interceptor holes.

(b) Restore the safety pin, remove the restraining load, and remove the base.

b. <u>British Release Fuse No. 6</u> (Fig. 124)

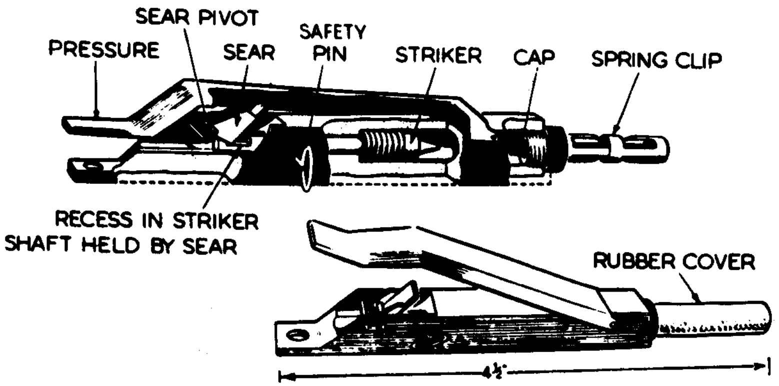


Figure 124

(1) Uses:

(Same as Pressure-Release Fuse M5.)

(2) Functioning:

(a) When a $2\frac{1}{2}$- to 4-pound pressure load is removed from the lid, the trip lever is pivoted forward and out of the striker notch by the pressure exerted by the striker spring.

(b) This permits the striker to be driven onto the percussion cap.

(3) Testing:

(a) Remove the base and set it aside.

(b) Stand the device on a board or similar flat surface, with the opening down. Exert pressure on the lid by grasping the fuse firmly in the palm of one hand. Remove the safety pin.

(c) Loosen the grip on the fuse. The striker should strike the board sharply.

(d) To re-cock, make sure the striker notch is up and then push the striker into the case with an unsharpened pencil or similar tool. Engage the trip lever in the striker notch. Close the lid and exert restraining pressure. Remove pencil, restore safety pin, and release restraining pressure. Screw the base into the device.

(4) Installation:

(Same as for Pressure-Release Fuse M5.)

(5) Priming:

Prime in the manner outlined for the British Pull Fuse No. 4.

(6) Arming and Disarming:

Generally the same as for Pressure-Release Fuse M5.

4. Pull-Release Fuses

Pull-release fuses are designed to fire when an adjusted spring tension is either increased or diminished.

a. Pull-Release Fuse M3 (Fig. 125)

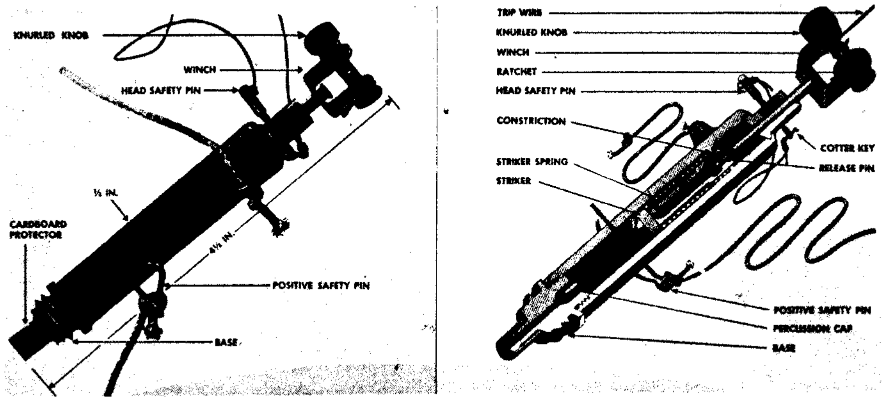


Figure 125

(1) Uses:

Used for booby traps.

(2) Functioning:

(a) After the device has been set with the proper spring tension (see Arming) any pull of from 6 to 10 pounds or a slight relaxation of the set tension will allow the jaws of the striker rod to clear the case constriction.

(b) This will permit the striker jaws to spread and release their grip on the stud of the release pin.

(c) The striker is then free and is driven onto the percussion cap by the striker spring.

(3) Testing:

(a) Remove the base and set it aside.

(b) Withdraw the positive safety pin.

(c) Stand the device on a board or similar surface with the open end down.

(d) Remove the cotter key from the head safety pin.

(e) Grasp the case with one hand and lift the winch assembly about one-quarter of an inch with the other hand, so that the head safety pin is centered in the slot.

(f) Withdraw the head safety pin with the fingers of the lower hand.

(g) Release or increase pull tension on the winch. The striker should strike the board sharply.

(h) To re-cock, push the striker into the case with an unsharpened pencil or similar tool. While maintaining pressure on the striker, insert the release pin from the opposite end of the case. Ascertain that the release pin stud is between the striker jaws. Hold the device in a vertical position, with winch end up, and ease off pressure on the striker. When the safety pin recess in the release rod is aligned with the wide portion of the head safety pin slot, insert the safety pin. Remove the pencil and restore positive safety pin and base.

(i) Inspect the winch mechanism to see that it is not defective.

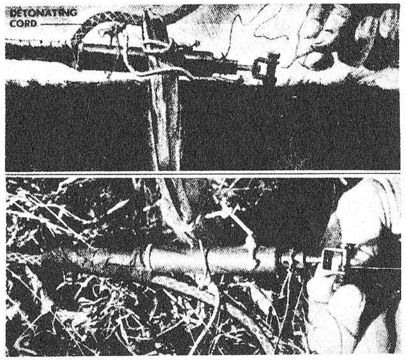
(4) Installation:

Booby traps (Fig. 126).

(a) Secure the fuse to a solid object. CAUTION: Do not anchor this fuse in a haphazard manner.

(b) Secure the trip wire tightly at a distant point. Extend it to the fuse and cut the wire.

(c) Connect the trip wire to the fuse by passing the free wire end through the hole in the winch drum. The wire should not be drawn so tight that it exerts tension on the fuse. Twist the free wire end about the trip wire to prevent slippage.



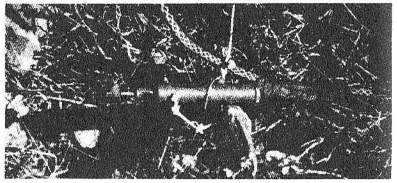


Figure 126

(d) Turn the knob of the winch assembly until the head safety pin is centered in the wide portion of the safety pin slot.

(e) The device can now be primed.

(5) Priming:

Equip the base with blasting cap and connect the primed fuse to the main charge.

(6) Arming:

Remove the head safety pin and then the positive safety pin.

(7) Disarming:

(a) Insert the safety pins, positive pin first.

(b) Remove the base.

(c) Relax the tension by pushing down the knurled knob and stripping off the wire.

C. Delay Fuses

1. Delay Fuse M1 (Time Pencil) (Fig. 127)

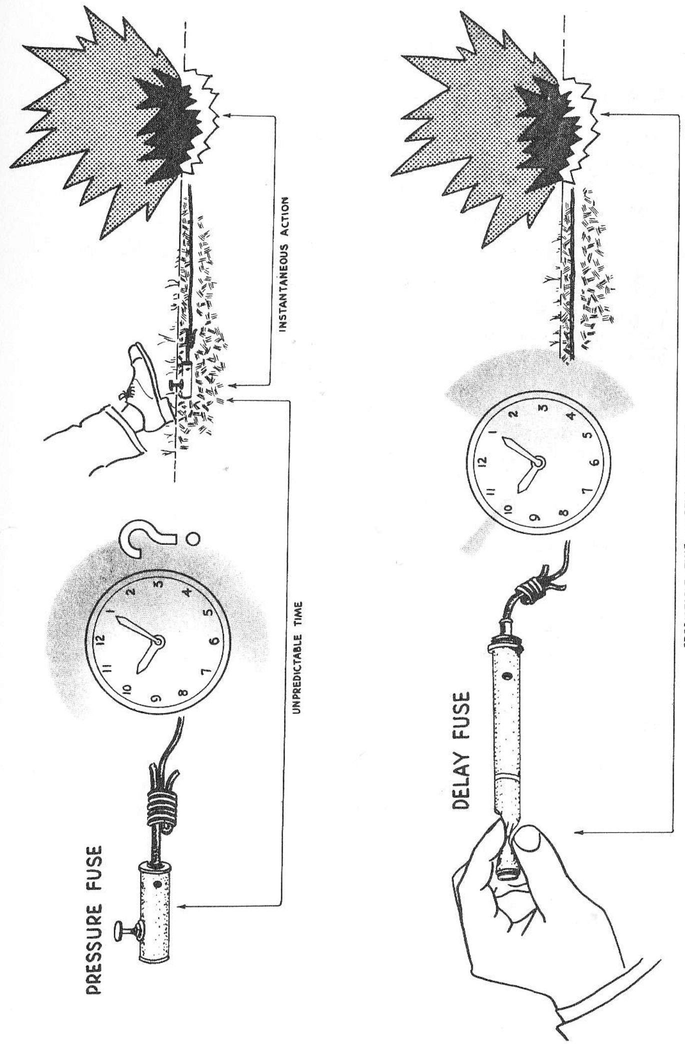


Figure 127

a. Uses:

Used for delayed-action charges.

b. Functioning:

(1) When the corrosive liquid contained in the ampoule is released, it weakens the striker restraining wire to a point where the wire is actually broken by the force exerted by the striker spring.

(2) This permits the striker to be driven onto a percussion cap.

c. Delay Range:

M1 delay fuses are manufactured in six different delay units. These may be distinguished from one another by the color of the identification and safety strip. The time delay is governed by the strength of the corrosive liquid, which is of a certain concentration for each color category. Delay periods are subject to wide variation, due to the influence that temperature imposes on the chemical reaction. Chart No. 10 shows the approximate delay periods of each fuse over a wide range of temperature.

d. Testing:

The time pencil is a one-time fuse, and so cannot be tested. It should be inspected to see that the striker has not fallen. This is done by glancing through the inspection holes.

e. Priming:

(Note: This device should never be primed with a blasting cap connected directly to the base. Instead, a short length of safety fuse should be interposed between percussion cap and detonator.)

(1) Attach the safety fuse to the base of the time pencil as is shown in Figs. 128 and 129A.

(2) Crimp the blasting cap to the free end of the fuse.

(3) Connect the primed fuse to the main charge.

TEMPERATURE		COLOR OF FUSE											
		BLACK		RED		WHITE		GREEN		YELLOW		BLUE	
C	F	OM	ST	OM	ST	OM	ST	OM	ST	OM	ST	OM	ST
-32°	-25°			8.5 hr.	3.3 hr.	3 days	1.3 days						
-18°	0°	8 hr.	2.5 hr.	45 min.	20 min.	17.5 hr.	8 hr.	2.6 days	1.2 days	8.5 days	3.8 days	23 days	10 days
-4°	25°	36 min.	16 min.	25 min.	11 min.	5.5 hr.	2.5 hr.	17 hr.	8 hr.	2 days	20 hr.	5 days	2.2 days
10°	50°	15 min.	7 min.	17 min.	8 min.	2 hr.	55 min.	6 hr.	2.7 hr.	14 hr.	6.0 hr.	1.3 days	14 hr.
24°	75°	9 min.	4 min.	15 min.	7 min.	1 hr.	27 min.	2.5 hr.	70 min.	5.5 hr.	2.5 hr.	11.5 hr.	5 hr.
38°	100°	5 min.	2 min.	8 min.	3.5 min.	32 min.	14 min.	70 min.	30 min.	2.5 hr.	65 min.	5.2 hr.	2.3 hr.
52°	125°	4 min.	1.5 min.	5 min.	2 min.	20 min.	9 min.	35 min.	15 min.	80 min.	36 min.	2.5 hr.	1.1 hr.
66°	150°	3 min.	1 min.	4 min.	1.5 min.	15 min.	6 min.	20 min.	9 min.	46 min.	21 min.	80 min.	36 min.

OM (Operational Median Time; probable time delay action will take): When two pencils are used in the same charge, the OM is the most likely timing. When a single pencil is used, the time should be increased by about 15 percent.

ST (Safe Time): The ST is the normally safe time. Timings shorter than the ST should not occur more often than once in a thousand trials. Red pencils should not be used below 0° F, nor Black pencils below 25° F.

Chart 10. Approximate Delay Ranges for M1 Delay Fuse

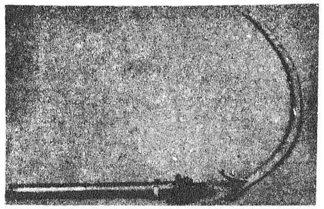


Figure 128

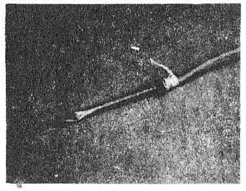


Figure 129A

f. Arming:

(1) Examine the fuse to see that the striker has not fallen.

(2) Crush the copper tube between thumb and forefinger as is shown in Fig. 129B. (Note: Never bend the flattened tube to one side, as this movement may break the restraining wire.)

(3) Check to see that the striker has not fallen. If it has, the pencil should be discarded. If the striker has not fallen, continue with step (4).

(4) Remove the safety strip.

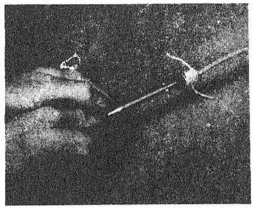


Figure 129B

g. Disarming:

It is hazardous to approach the time pencil after it has been armed. If an armed time pencil must be disarmed, a nail or similar instrument should be placed through the inspection holes.

2. Acetone Celluloid (A.C.) Delay Fuse (Fig. 130)

a. Purpose

To initiate an explosive charge after a predetermined time delay. The A.C. Delay Firing Devices are usually attached in pairs to opposite ends of a charge to improve the accuracy of the time delay and ensure that one delay is always at least in the horizontal position. The A.C. Delays are not designed to function if positioned with the thumbscrew end down.

b. Description

The kit containing the A.C. Delay Firing Device contains 13 parts: A.C. Delay body, detonator, 9 delay ampoules, wrench, and a small tube of luting compound. The A.C. Delay body is a metal tube containing a spring-loaded firing pin which is restrained by a cellulose disc. One end of the body is threaded to receive the detonator and the other end is fitted with a removable cap to provide a means for inserting an ampoule of solvent.

The assortment of delay ampoules permits a selection of delay firing periods, the delay depending upon the kind of solvent in the ampoule. The short-time ampoules are identified by the color of the solvent and the others by the color of the paint with which the ampoule is marked. The time delay obtainable with each ampoule, at various levels of temperature, is given in Chart 11. These delay figures are subject to 25-percent deviation either way red through violet, and 60-percent deviation either way black through gold.

c. Installation Procedure

(1) Unscrew the cap on the delay body.

(2) Select the proper ampoule according to the time delay desired and the prevailing temperature at the target. Insert the ampoule, pointed end first, into the delay body.

(3) If the explosive device is to be detonated under water or some other liquid, the threads on the delay body must be covered with the luting compound provided in the kit. Apply the luting compound to the threads on the cap end first.

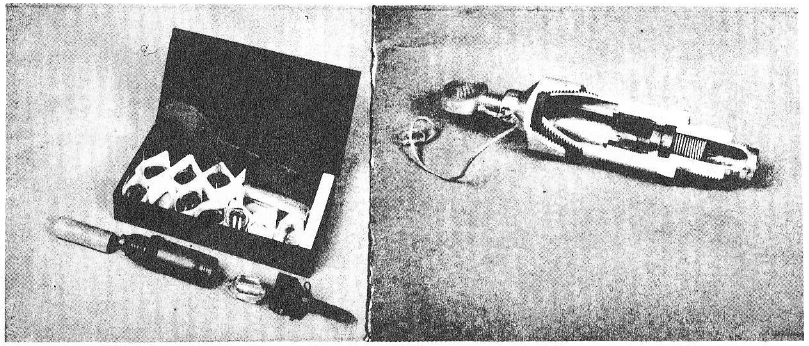


Figure 130

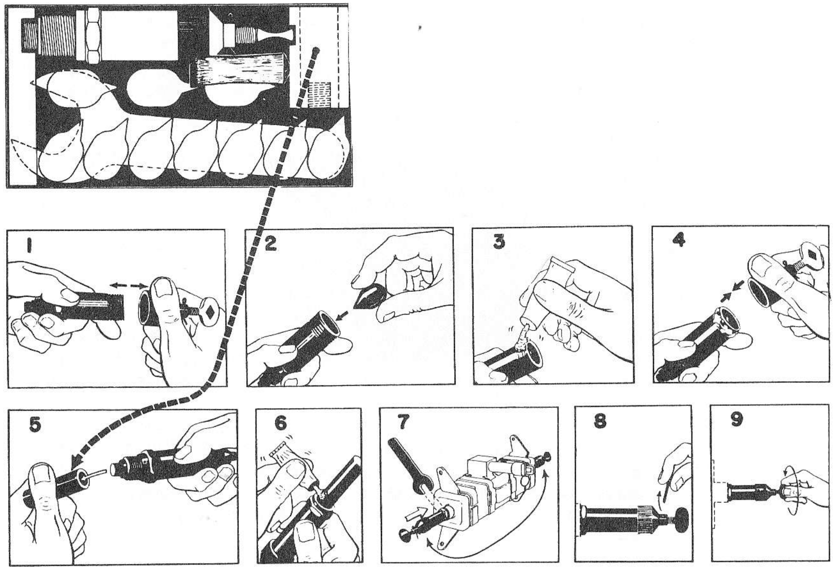


Chart 11. Ampoule-Delay Periods

COLOR OF SOLVENT					TEMPERATURE		COLOR OF BAND			
Red	Orange	Yellow	Green	Violet	C	F	Black	White	Clear	Gold
9 Hours	26 Hours	50 Hours	132 Hours	378 Hours	5^{o}	41^{o}				
6 Hours	11 Hours	21 Hours	45 Hours	161 Hours	15^{o}	59^{o}	17 Days	32 Days	98 Days	168 Days
$2\frac{1}{2}$ Hours	7 Hours	15 Hours	21 Hours	103 Hours	25^{o}	77^{o}	10 Days	18 Days	49 Days	84 Days
2 Hours	5 Hours	11 Hours	16 Hours	59 Hours	35^{o}	95^{o}	5 Days	9 Days	$24\frac{1}{2}$ Days	42 Days

(4) Screw the cap on the delay body.

(5) Screw the detonator on the delay body.

(6) For use under water or other liquid, apply the luting compound to the threads on the detonator end of the delay body.

(7) Screw the assembled A.C. Delay Firing Device into the explosive device and tighten with the wrench provided in the kit.

(8) Arm the delay element after the assembled explosive device and firing device is placed at the target. To arm the firing device, first remove the cotter key in the thumbscrew.

(9) Complete the arming procedure by turning the thumbscrew into the delay body until the ampoule is crushed. Then turn the thumbscrew three full turns in the opposite direction.

3. Clockwork Delay Fuses

a. Clockwork Firing Device (24 Hr.)

The main purpose of this device is to fill in the gaps left by the chemical firing devices and to provide a more accurate delay. This device can be set for any time from 15 minutes to $23\frac{3}{4}$ hours with a probable error of $1\frac{1}{2}$ minutes. This device can be used to detonate standard Army demolitions charges, dust initiators, all limpets, or be used by itself. This clockwork is relatively insensitive to temperature changes and will perform satisfactorily from -40 F to 160° F.

The device is packaged in a can, complete with instructions and ready for use. It has an Army coupling base to which a blasting cap may be crimped and an M-34 detonator which is used to detonate both the limpet and dust initiator. The operator, can, if he wishes, test the unit by firing it into the positive safety. A cocking device is included, and the unit can readily be cocked.

The clock dial is luminous, and the device can be set in the dark. When it is used with the limpet, the device, although previously set, can be armed under water after the limpet has been placed.

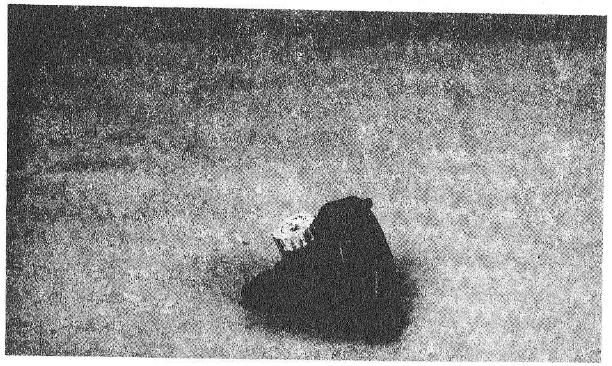
The clock itself measures approximately $2\frac{1}{2}$ by $2\frac{1}{2}$ by $1\frac{1}{2}$ inches and weighs $1\frac{1}{2}$ pounds. The packaged unit measures approximately $3\frac{1}{2}$ inches in diameter by 5 inches in height, and weighs 3 pounds.

D. Miscellaneous Fuses

1. Concussion Detonator M1 (Fig. 131)

a. Use:

The concussion detonator is a mechanical firing device which is actuated by a concussion wave of a blast. It can be used to fire several charges simultaneously without the charges being interconnected by wires or detonating cord. A single charge fired in any way, in water or in air, will detonate all charges which are equipped with concussion detonators and which are within range of the main charge or each other. Chart 12 gives ranges at which concussion detonators function reliably in either air or water.



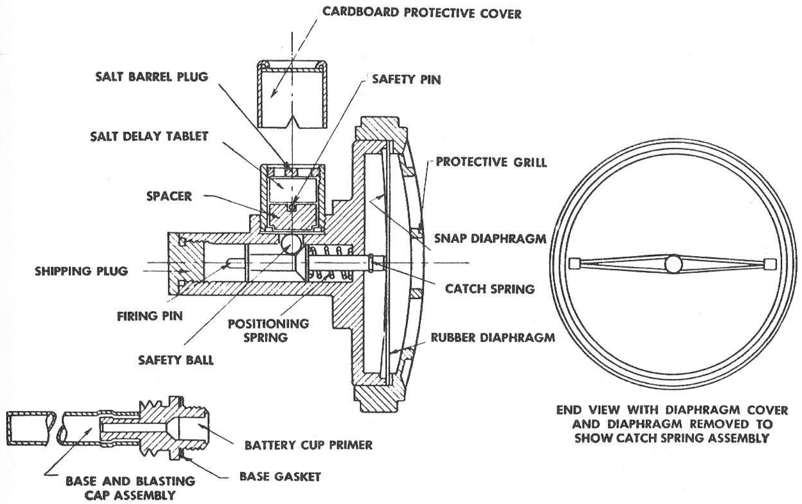


Figure 131. Concussion Detonator

b. Functioning:

The detonator consists of a diaphragm-type, spring-loaded striker restrained by a safety ball. The ball is held in place against the beveled shoulders of the striker by a spacer and a safety pin. When the safety pin is pulled, the positioning spring pushes the striker forward. This moves the safety ball and spacer upward, freeing the striker. A concussion wave strong enough to overcome the snap diaphragm makes the detonator function.

c. Testing:

Examine the fuse to see that threads, gaskets, salt table well, etc. are clean and free of corrosion.

d. Water Application:

(1) Delay Tablets

To provide safety while arming the device in water, two water-soluble time-delay salt tablets are supplied with the detonator. The blue tablet gives a delay of approximately $3\frac{1}{2}$ minutes, and the yellow tablet approximately 7 minutes. However, since dissolving time of the salt tablets varies with surf conditions and water temperature, tests should be made to determine the arming time before the charge is prepared and installed. The test is made by submerging the device to the proper depth under conditions similar to those anticipated in the actual operation, and observing the dissolving time of the salt tablet.

(2) Arming Time

Since the salt tablets become soft before they are completely dissolved, detonators are dangerous after one-half of the dissolving time elapses. Personnel should be withdrawn from the danger area within half of the arming time, since a nearby concussion from enemy bombs or shells could fire the device. The initiating charge is not fired until the complete arming time of the delay tablet has elapsed.

(3) Cardboard Protective Cover

A cardboard protective cover fits over the salt tablet well to prevent the tablet from dissolving during

underwater installation. The cover should not be removed until the last possible moment before pulling the safety pin.

(4) Ranges and Depth

Detonators frequently function at ranges greater than those given in Chart 12, but their reliability is not assured. The device should not be used in surf at a greater depth than 15 feet. The snap diaphragm functions by hydrostatic pressure at a depth of 25 feet.

Chart 12. Operating Range of Concussion Detonators

Initiating Charge (in pounds)	In Water		In Air
	Depth of Water (in feet)	Recommended Range (in feet)	Recommended Range (in feet)
0.5	2	10	. . . .
0.5	4	50	. . . .
0.5	6	80	. . . .
0.5	8	80	. . . .
2.5	. . . .	. . . .	15
2.5	2	20	. . . .
2.5	4	80	. . . .
2.5	6	80	. . . .
2.5	8	150	. . . .
5	. . . .	. . . .	20
10	. . . .	. . . .	35
15	. . . .	. . . .	35
20	. . . .	. . . .	35
20	2	20	. . . .
20	4	80	. . . .
20	6	180	. . . .
20	8	260	. . . .

e. Priming and Installation of Fuse in Water:

(1) If a long delay is necessary, remove the blue tablet and install the yellow tablet, taking care that spacer, safety pin, and cardboard protective cap are properly installed.

(2) Discard the shipping plug and carefully insert the base and the blasting cap assembly, with its associated gasket, to form a tight waterproof fit.

(3) Fit the blasting cap and the base into a threaded cap well of the charge, or connect the blasting cap to the charge with a short length of detonating cord. Waterproof all openings of the blasting cap and detonating cords.

(4) Wire or tie the detonator to the charge and make sure the detonator diaphragm is free of obstructions and is clearly exposed.

(5) Place all charges in water, where required.

(6) Remove the cardboard protective covers and pull the safety pin.

(7) Evacuate the danger area within one-half of the arming time of the delay tablets in use.

(8) Prime the initiating charge with a delay that will permit full arming (complete dissolution of the delay tablet/s). Wait the full arming of the delay tablet before firing the initiating charge.

f. Atmospheric Application:

(1) Preparing Device

When the device is used in air, remove and discard the salt delay tablet. Check the device to make sure the catch spring restrains the firing pin when the safety pin is withdrawn and that the spacer releases. When the safety pin is withdrawn, the firing pin should move forward approximately one-sixteenth of an inch, but it should not fall or fly out of the barrel of the device. If the firing pin falls or flies out of the barrel, discard the device. Remove the tablets and check the firing pin before fitting the base and the blasting cap assembly to the device. Replace the spacer and safety pin and screw the base and blasting cap assembly into the threaded barrel in place of the shipping plug.

(2) Range

When used in air, all charges equipped with concussion detonators should be placed reasonably equidistant and at least 15 feet from the initiating charge. When placed too close to another charge in air, the concussion wave frequently causes the diaphragm to be impaled on the firing pin, resulting in a misfire.

g. Priming and Installation of Fuse in Air:

(1) Remove the salt delay tablets.

(2) Check the restraint of the firing pin by removing the safety pin and checking to see that the firing pin is held in place by catch spring.

(3) Replace the spacer and safety pin.

(4) Discard the shipping plug and carefully insert the base and the blasting cap assembly, with its associated gasket, to form a firm fit.

(5) Fit the blasting cap and the base into the threaded cap well of the charge, or connect the blasting cap to the charge with a short length of detonating cord.

(6) Wire or tie the detonator to the charge and make sure that the detonator diaphragm is free of obstructions and is clearly exposed.

(7) Place all charges with the detonator diaphragms facing the initiating charge.

(8) Withdraw the safety pins and evacuate the area. The devices are immediately armed.

(9) Fire the initiating charge when personnel are clear of the danger zone.

h. Disarming:

(1) Depress the spacer and force the safety ball against the shoulder of the firing pin.

(2) Insert a small nail through the holes in the salt barrel.

(3) Remove the base and the blasting cap assembly from the device.

SECTION 3. SPECIAL PURPOSE FUSES

A. General

Some of the items described in this section of the Handbook may not be available for field use at the present time. It is expected, however, that eventually all of them will be available.

B. Railroad Torpedo or Fog Signal (Fig. 132)

1. Use

Used as a train-actuated fuse to fire derailment explosive charges. (This will be discussed in the chapter on railroad transportation in Volume III, to be published at a future date.)

2. Priming and Arming

a. Connect the charges with detonating cord. Run the detonating cord from the first charge along the base of the rail for about 10 feet (3 meters) toward the train to the firing device. If the direction of the train's movement is not known, make a similar installation at both ends of the charges.

b. Holding the firing device in the left hand, roll back the rubber sleeve to expose the spring snout.

c. Remove the wood plug in the spring snout. Do not permit the spring snout to point downward, or else the black powder within the firing device will pour out.

d. Insert a nonelectric blasting cap in the spring snout.

e. Roll the rubber sleeve down over the spring snout and out as far as possible over the blasting cap. Be sure that the rubber sleeve grips the blasting cap firmly.

f. Place the free end of the detonating cord alongside the blasting cap, allowing at least 3 inches (8 centimeters) of cord to extend past the blasting cap. Tape the detonating cord to the blasting cap so that the cord and cap are pressed tightly together.

g. Place the firing device on the head of the rail, with the metal hook on the bottom of the firing device pressed against the outside edge. Press the lead strap over the head of the rail

and against the web so that the firing device is held firmly in place. The spring snout and blasting cap must be over the outside edge of the rail (see Fig. 132).

3. Disarming

a. Remove the fuse from the rail, disconnect the detonating cord, and pull the cap out of the spring snout.

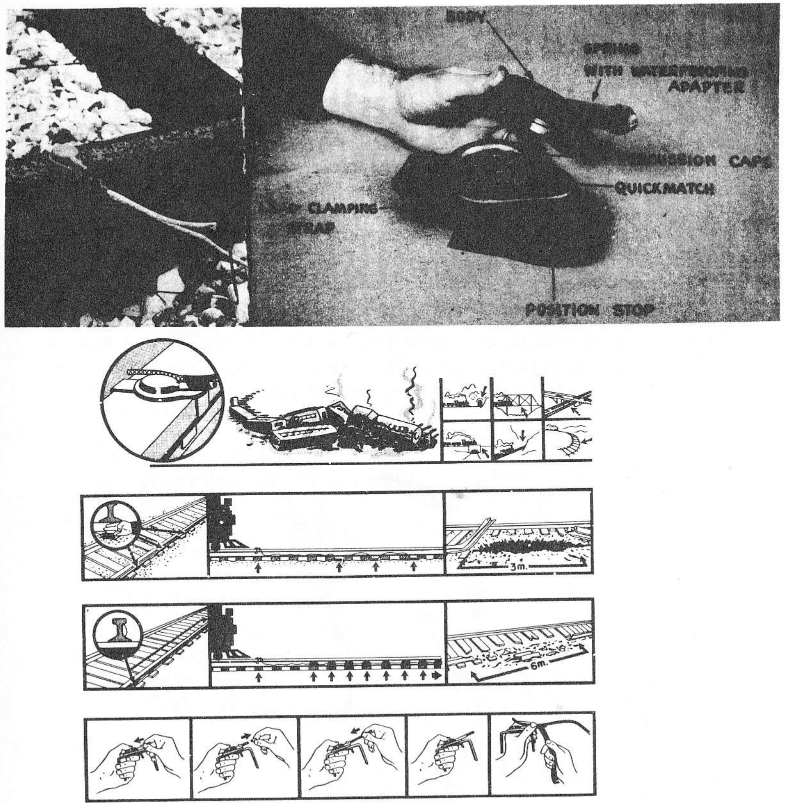


Figure 132

C. Barometric Fuse (Fig. 133)

1. Use

Pressure-operated fuse to fire explosive charges in airborne aircraft.

2. Functioning

As the aircraft in which a primed barometric fuse is placed approaches an altitude of 1,500 feet above the ground, there exists a difference in atmospheric pressure between the air within the response chamber of the fuse and the air at 1,500 feet altitude. The air within the response chamber is under ground-level atmospheric pressure, which is greater than the pressure at 1,500 feet altitude, and therefore expands; this expansion causes the response-chamber diaphragm to belly out. The latch keeper, being attached to the response-chamber diaphragm, moves outward, permitting the roller arms of the latch assembly to enter the recesses of the latch keeper. This removes the shoulders of the latch arms from the rear firing pin groove, and the firing pin is driven against the detonator by the firing pin spring.

(Note: The barometric fuse contains a built-in safety device called the capillary tube. The capillary tube, which connects the response chamber and drain chamber, acts as a compensator by permitting a gradual equalization of the response-chamber and outer-air pressures during a slow change of (ground) temperature or pressure. Pressure always drains from the response chamber, since the drain chamber is open to the atmosphere through a pinhole in one end of the device. Thus, for the barometric fuse to function there must be a rapid ascent, a minimum of 800 feet per mile , or a rapid pressure change.)

3. Testing

Hold the fuse in the vertical position with the detonator end down and remove the hairpin and jamming safety pins. The device should not operate. Insert the safety pins and proceed with priming.

CAUTION: If the device operates after the safety pins have been removed, it is defective and should not be used.

4. Priming

a. Load the sleeve with plastic explosive to within $1\frac{1}{2}$ inches from the top.

b. Fashion a detonator recess in the explosive with one finger or with a stick.

c. Screw the M-34 detonator, with which the fuse is issued, on the threaded tube of the device.

d. Fit the detonator and fuse into the open end of the explosive-loaded sleeve, making sure that the detonator is well seated in the explosive mass.

e. Lock the sleeve onto the fuse by passing the metal clamping strap through the clamping eye and bending it back to form a crease.

5. Installation and Arming

a. Locate a critical and vulnerable point of the target aircraft (main wing or stabilizer supports, fuel tanks, landing gear, cockpit, etc.).

b. Remove the adhesive tape holding the arming strap and remove the hairpin safety pin.

c. Tighten the fuse arming screw with the arming strap.

d. Strip the adhesive tape off the jamming safety and remove the latter. This should come out easily. If resistance is encountered, do not force removal, since a tight jamming pin indicates that the firing mechanism is improperly cocked (the charge would probably fire if the pin were withdrawn). Instead, remove the explosive and detonator and retest the fuse.

e. Place the device.

(Note: There is now under development a barometric fuse which will detonate at 1,500 feet altitude without regard to the rate of climb.)

Figure 133A

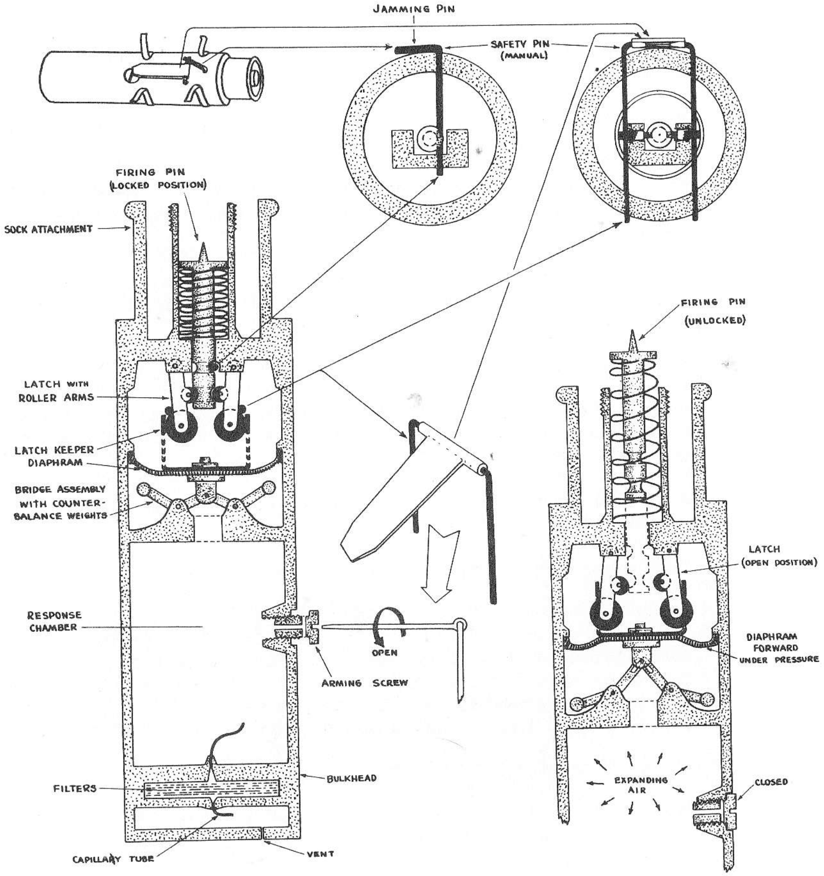


Figure 133B

D. Photoelectric Fuse (Fig. 134)

1. General

Although this fuse is not available today, it is described in order to afford the reader an idea of still another operating principle.

2. Use

To cause the detonation of explosive charges when a target (train, truck, or automobile) on which the device is placed passes quickly from one light extreme to another, as when entering a tunnel during the daylight hours. (Note: This type of fuse may be designed to operate in one way--either from illumination to darkness or from darkness to illumination.)

3. General Functioning (Illumination to Darkness)

The photoelectric cells are interposed between a battery and ground. As long as these cells are exposed to the proper light intensity they (cells) impose no resistance to the flow of electric current. When these cells are suddenly deprived of light, however, their resistance becomes so great that the electric current is forced to take an alternate circuit. This causes a change in voltage in an electronic circuit which in turn fires a special type of blasting cap.

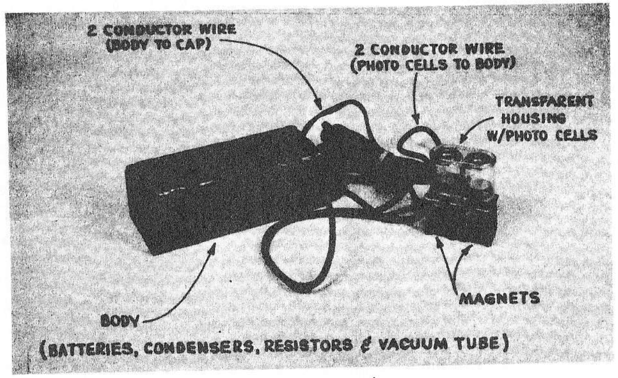


Figure 134

E. Radio Fuse

1. General

The armed forces of several countries have successfully developed radio-controlled firing devices capable of receiving coded radio signals from remote points. There is a fuse of this type available for issue to the field, along with a booklet of instructions for its use.

Essentially these devices consist of the following: a radio receiver incorporating an antenna and a charge-firing relay, and one or two batteries--depending on whether a single battery is strong enough to power both the radio and the external blasting cap circuits. The size of such cases varies from miniature-cigar-box types to much larger units. Generally speaking, the large units are capable of receiving from longer ranges.

Associated transmitting equipment may vary from small portable sets to large field sets.

To minimize the possibility of jamming and premature firing from other than the parent transmitters, special coded signals may be set on specific frequencies.

F. Sensing Fuse

1. General

Sensing fuses are a class of specialized mechanisms which provide the fuse function upon receipt of a certain stimulus. Such a stimulus may be a light change, temperature change, audio change, water salinity change, pressure change, body capacitance, physical vibration, etc.

Sensing fuses may function after reception of one or a variable number of stimuli responses, and thereby permit specific target selection, e.g., detonation of a tunnel derailment charge when the last of a series of 10 trains enters the tunnel.

Once the fuse and associated charge have been primed, placed, and armed, the control of the device passes from the saboteur to the target itself and/or to natural phenomena.

The barometric and photoelectric cell fuses previously discussed are types of sensing fuses. Other types may take the form of compact electronic units composed of amplifier, battery, and

transducer. The transducer is the device which is actuated by the stimulus and produces an electric signal which is amplified to permit detonation.

(Note: Although many of these fuses are not available today, the possibility exists that they may be in the near future. In some cases manufacture of them would require little more than modification of certain commercially available items.)

SECTION 4. HOMEMADE FUSES

A. General

The homemade fuses described in this Section represent a few of the hundreds of possibilities that exist. Although these improvisations are clumsy by comparison with readymade fuses, they are nonetheless necessary when regular issue items are not available.

B. Improvised Electric Blasting Cap (Fig. 135)

1. General

Since electric blasting caps are not always available when needed, it may be expedient to discuss how they may be improvised from simple materials.

2. Materials Required

a. Nonelectric blasting cap.

b. Chlorate-sugar mixture.

c. Length of stranded copper wire.

d. Tape.

3. Construction

a. Double the length of wire and remove the insulation at the bend, as is shown in Fig. 135.

b. Remove all except one wire strand from the bend, being careful not to nick the one strand remaining.

c. Form a bend in the single strand of wire (see Fig. 135) and tape the insulated legs together.

Before proceeding, it is advisable to make a power test, using a duplicate wire loop for the purpose. This is done by touching the wire ends to the terminals of the operational power source. If the bared strand does not heat to incandescence within a fraction of a second, the available power is unsuitable and must be increased. The test should also be applied to the cap wire joined to the firing wire.

d. Cut a paper insulator and insert it in the cap, as is shown in Fig. 135. Notice that the insulator protrudes about one-half inch from the cap opening.

e. Fill the blasting cap with chlorate-sugar (see First Fire Mixtures, Chapter III.) to within one-quarter of an inch from the open end (three-quarters of an inch from the top of the paper insulator). Tape the cap to a small stick, as is shown in Fig. 135.

f. Insert the loop of wire into the blasting cap so that it contacts the chlorate-sugar mixture. Tape the leg wires so that the loop remains in the proper position.

g. Gently fold the insulator about the leg wires and tape, being careful not to disturb the bared wire inside the cap.

(Note: Do not remove the blasting cap assembly from the stick. Secure the leg wires to the stick in such a way that the joint of cap and wire cannot be disturbed by leg wire handling.)

4. Priming

Detonating cord should be taped to the blasting cap without disturbing the cap-wire juncture.

C. Dry Cell Battery Clamp (Fig. 136)

1. General

Flashlight dry cells may be used singly or in clusters to provide electric current for homemade fuses. The difficulty of permanent connections can be overcome by fashioning a simple clamp device like those shown in Fig. 136.

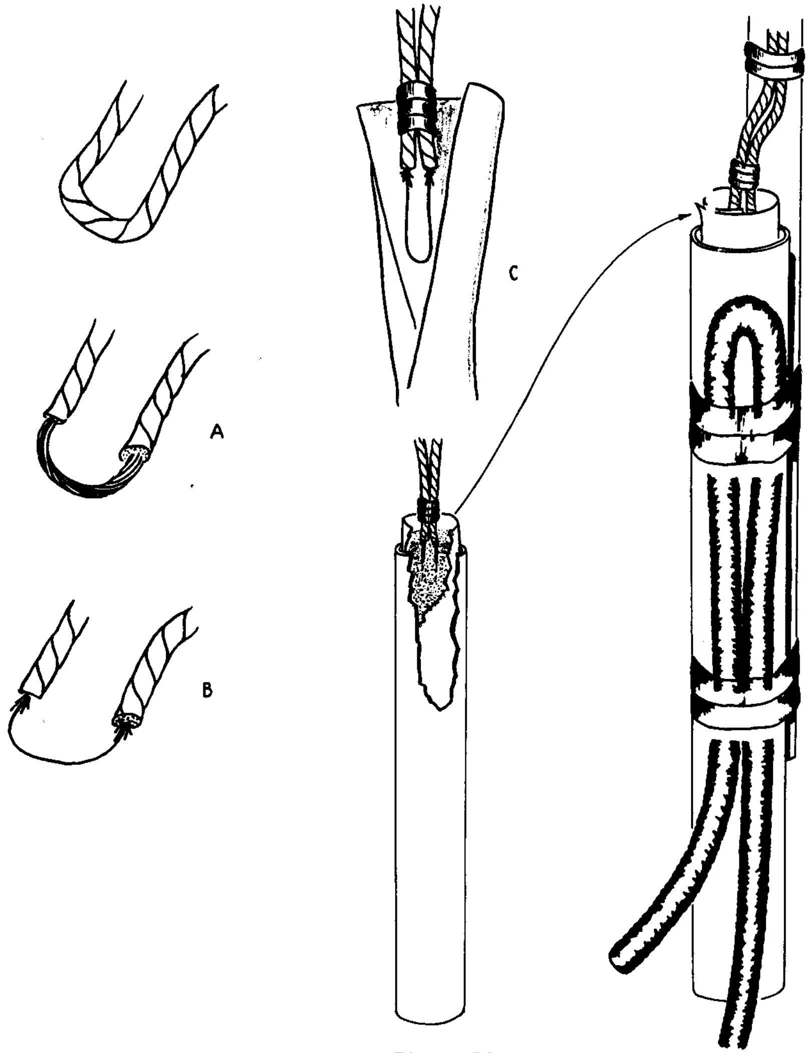


Figure 135

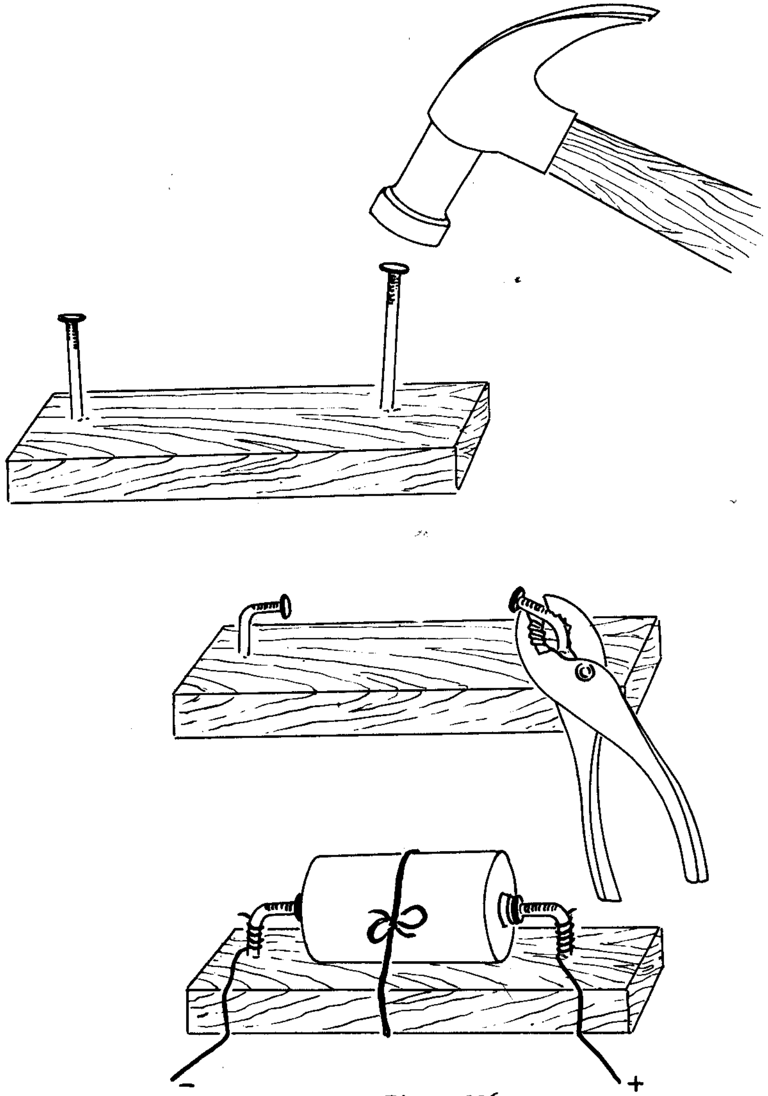


Figure 136

D. Cap Loop Booby Trap (Fig. 137)

1. Materials Required

a. Flashlight battery.

b. Electric blasting cap.

2. Construction

(See Priming and Arming.)

3. Uses

Used as pull-type booby trap fuse.

4. Priming and Arming

a. Strip 3 inches of insulation from the ends of the blasting cap leg wires.

b. Bend one of the bared wire ends into a loop.

c. Thread 1 foot of the other leg wire through the loop and bend the second wire around the first to form a second loop. The loops should be about 10 inches apart.

d. Cut one of the blasting cap leg wires in half. Remove the insulation from the ends of the cut wire.

e. After ascertaining that the bared loops are separated by several inches, attach the ends of the cut wire to the battery terminals.

f. Connect the blasting cap to the main charge.

5. Functioning

a. When a pull is exerted on either leg wire, the bared loops are drawn together. This completes the circuit and fires the cap.

6. Disarming

a. Without unduly disturbing the cap leg wires, cut or otherwise remove the power source.

b. Separate the blasting cap from the main charge.

E. Pull Fuse, All Ways (Fig. 138)

1. Uses

Used as pull or pull-release booby trap fuse.

2. Materials Required

a. Length of baling wire or similar wire.

b. Board.

c. Nails.

d. Battery.

e. Trip wire.

f. Electric blasting cap.

3. Construction

a. Fashion a 2-inch ring at one end of a length of baling wire; bend the remainder of the wire so as to form a simple strand and nail it to the board.

b. Bend the second length of baling wire so that an inch or two of one end projects through the ring; form a base and nail it to the board. The projecting wire should be bent so as not to touch any part of the ring.

(Note: Do not anchor the lower wire ends to the board, for they should be free to facilitate the attachment of battery and cap leads.)

4. Priming and Arming

a. Secure the fuse in the firing position and connect one or more trip wires between the projecting wire and distant points.

b. Divide one blasting cap leg wire. Remove the insulation from the ends of the cut wire and attach them to the terminals of the power source.

c. After ascertaining that the fuse ring and projecting wires are not touching one another, attach the cap leg wires to the anchor ends.

d. Connect the blasting cap to the main charge.

(Note: This fuse should be tested to see that the electric power source is sufficient to set off the blasting cap.)

5. Functioning

When a lanyard or trip wire is pulled sufficiently hard, the center projection contacts the outer ring. This completes the electric circuit and causes the blasting cap to detonate.

6. Disarming

a. Without disturbing the trip wires, detach the cap leg wire from the power source terminals.

b. Remove the cap from the main charge.

F. Drip Delay Fuse (Fig. 139)

1. Use

Used as an accurate short-time delay fuse for sabotage operations.

2. Materials Required

a. A bucket-type container.

b. Small float (wood or cork).

c. Small-diameter float mast.

d. Battery.

e. Electric blasting cap.

f. Tape.

3. Construction

a. Drill a small hole in the container, as is shown in Fig. 139.

b. Cut 3 inches from one blasting cap leg wire. Strip the insulation from it and bend it into a ring, as shown in Fig. 139.

c. Cut sufficient wire from the blasting cap leg wires to fashion the ring-supporting "spider." Thread "spider" legs through holes drilled at the rim of the container and secure to the container.

d. Attach the mast to the center of the float.

e. Cut 10 inches from one blasting cap leg wire. Strip 3 inches of insulation off one end of this 10-inch length of wire, and bend the bared portion so that it is perpendicular to the insulated leg. Secure the insulated leg to the float mast with tape so that the bared segment is at the top (see Fig. 139).

4. Priming and Arming

a. Divide one of the blasting cap leg wires and connect battery or other source of power.

b. Pour water into the container. This will lift the float assembly and break the contact between the bared mast wire and the ring.

c. After ascertaining that no closed circuit exists, attach one blasting cap wire to the bared mast wire and the other to the ring.

d. Connect the blasting cap to the main charge.

(Note: This fuse should be tested prior to operational use.)

5. Functioning

As the water drips from the hole at the base of the container, the float assembly moves downward. Ultimately, the bared mast wire descends to the level of the ring; the electrical circuit is then completed, causing detonation of the cap. The time delay is influenced by the size of the container drip hole, the amount of water in the container, and the travel distance of the mast.

6. Disarming

a. Lift the mast and remove the blasting cap wires from the power source.

b. Remove the cap from the main charge.

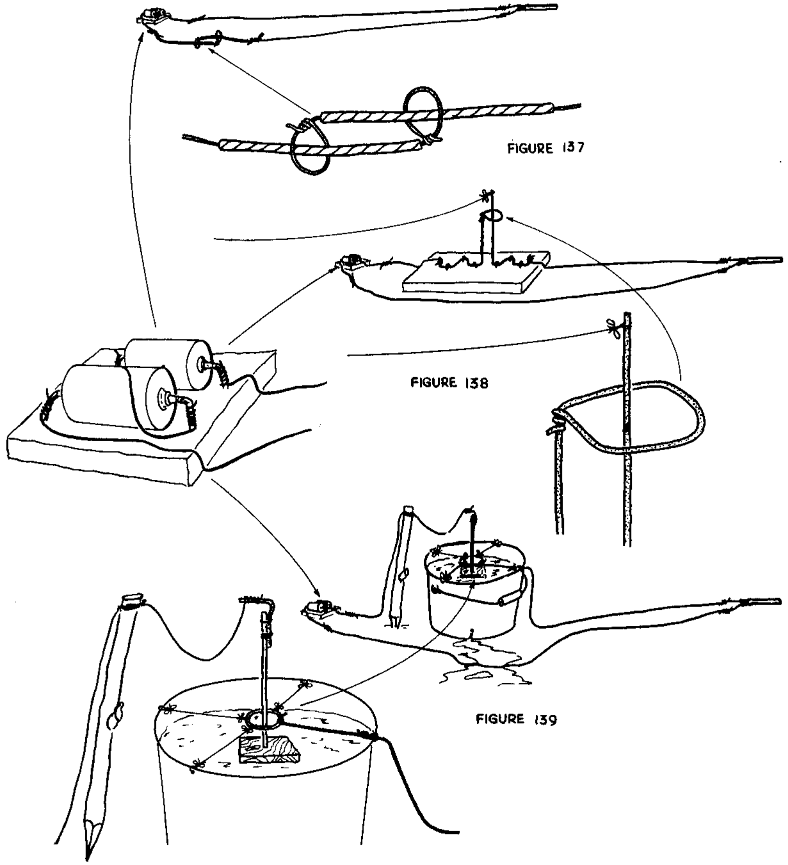


FIGURE 137

FIGURE 138

FIGURE 139

G. Expansion Delay (Fig. 140)

1. Use

Used as a moderately accurate delay fuse for sabotage operations.

2. Materials Required

a. A small bottle or test tube.

b. Dried beans, peas, or grain.

c. Two small screws (preferably of copper or brass).

d. Small block of cork or wood.

e. Battery.

f. Electric blasting cap.

3. Construction

a. Cut stopper and float from wood or cork. Stopper should fit snugly into container. Float should be cut to a smaller diameter and allowance should be made for slight expansion.

b. Insert the screws at the center of both stopper and float.

c. Drill a lead wire hole through the stopper.

d. Mount the tube or bottle on a firm base.

4. Priming and Arming

a. Pour the required amount of beans or other material into the container and pour in enough water to cover them.

b. Thread one lead of an electric blasting cap through the stopper hole and attach it to the float screw. Place the float inside the container.

c. Divide the remaining blasting cap leg wire and connect battery or other source of power. Attach the free end of the leg wire to the stopper screw.

d. Carefully insert the stopper into the container.

e. Connect the blasting cap to the charge.

(Note: This fuse should be tested prior to operational use.)

5. Functioning

As the dried material absorbs water it will expand and exert an upward pressure on the float. As expansion continues the float and stopper contacts will ultimately meet. This closes the electric circuit and causes the cap to detonate. The time delay is influenced by the amounts and ratios of water to beans and by the travel distance of the float. Usually, delays are from $\frac{1}{2}$ to 2 hours.

6. Disarming

a. Remove the blasting cap wires from the power source.

b. Remove the cap from the main charge.

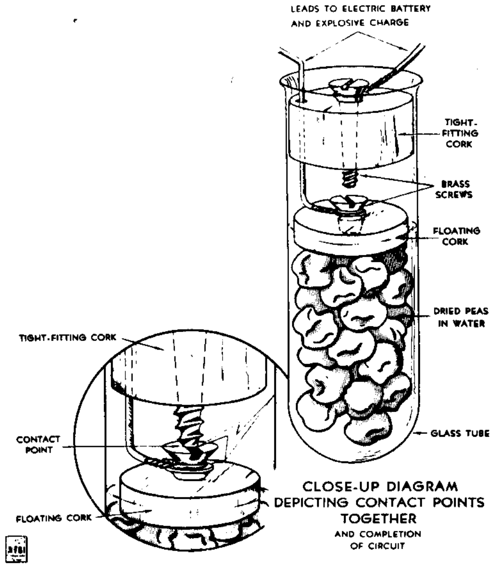


Figure 140

H. Screen Fuse (Fig. 141)

1. Use

Used as a bullet-triggered instantaneous firing system for derailment and ambush operations.

2. Materials Required

a. Two square feet of window-type screen (preferably of copper).

b. Large sheet of plastic, rubber, or paper.

c. Four frame sticks ($\frac{1}{2}$ inch in diameter by 18 inches long).

d. Cord.

e. Battery.

f. Electric blasting cap.

3. Construction

a. Cut the screen into two pieces of equal size (about 1 square foot each).

b. Weave a short length of wire (priming lead) which has been cut from a blasting cap lead into each piece of screen. This wire should be about 6 inches long, should be bared, and should protrude from the screen about 3 inches.

c. Cut two insulators (plastic, rubber, or paper) into rectangles 15 by 24 inches in shape.

d. Center each piece of screen on an insulator. Fold the long ends of the insulator back over the screen, being careful not to puncture the insulator.

e. Wrap each insulator flap tightly about a frame stick to within an inch of the screen edge, as is shown in Fig. 141.

f. Place the screens and insulators back to back and lash the frame sticks of one screen to those of the other, as is shown in Fig. 141.

(Note: If light-reflecting materials are used, paint, soot, etc. should be used to soften the glare.)

4. Priming and Arming

a. Place the fuse in the firing position by suspending it between support stakes or saplings (see Fig. 141).

b. Divide one of the blasting cap leg wires and insert the battery or other power source.

c. After it is ascertained that the screens are not in contact with one another, the blasting cap leg wires may be attached to the screen priming leads.

d. Connect the blasting cap to the main charge.

(Note: This fuse should be tested prior to operational use. The bullet hole through the insulators may be patched. The blasting cap should be placed underground to prevent fragments of it from damaging screens and battery.

5. Functioning

As the bullet passes through successive layers of screen, insulators, and screen, the circuit is completed, causing the blasting cap to detonate.

6. Disarming

a. Detach the blasting cap wires from the power source.

b. Remove the cap from the main charge.

I. Clockwork Delay Fuse (Fig. 142)

1. Use

Used as an accurate time-delay fuse for sabotage operations. The maximum delay is about $11\frac{1}{2}$ hours.

2. Materials Required

a. Pocket watch with celluloid crystal.

b. Small screw (preferably of brass or copper).

c. Battery.

d. Electric blasting cap.

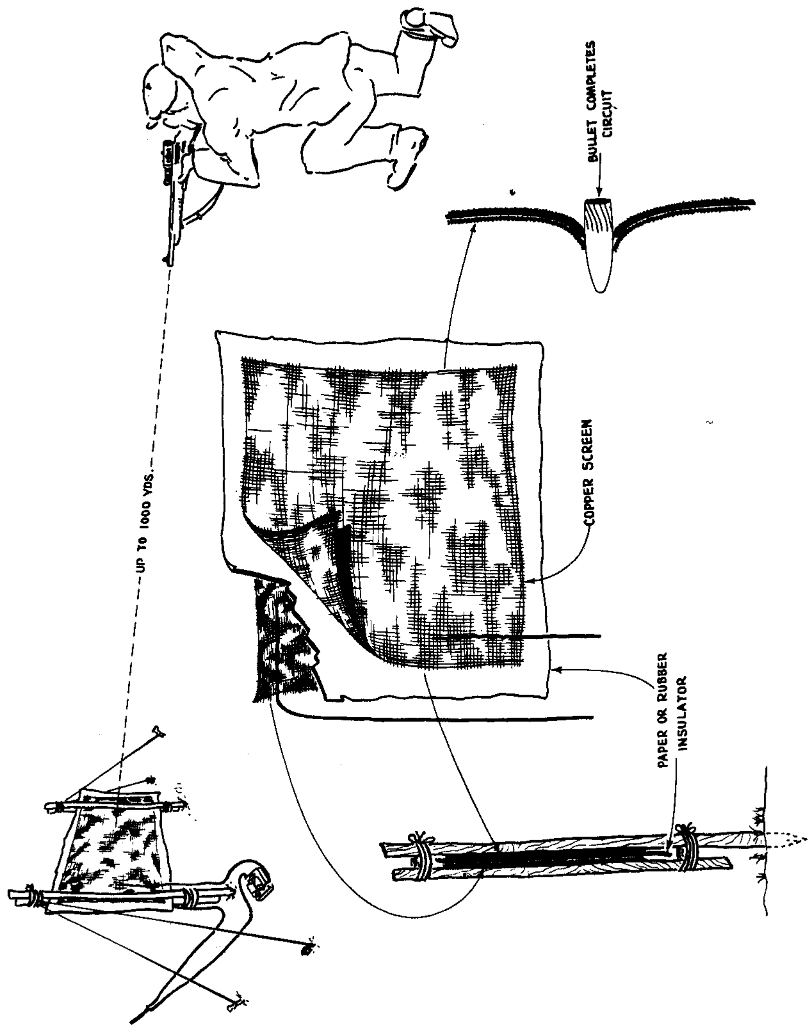


Figure 141

3. Construction

a. Remove the crystal cover from the watch.

b. If a delay of less than 55 minutes is desired, remove the hour hand; otherwise, remove the minute hand.

c. Drill a small hole (about one-quarter inch from the center) in the crystal and insert the screw. Tighten the screw so that it projects from the concave side of the crystal.

d. Snap the crystal cover back onto the watch.

e. Manipulate the watch stem to see that the hand will contact the screw. If the hand passes beneath the screw, tighten the screw until it is in the path of the hand.

f. Attach the watch to a board or some other base with tape, glue, etc.

4. Priming and Arming

a. Wind the watch.

b. Set the watch by turning the hand away from the screw (in a counterclockwise direction) the amount necessary to assure the desired delay.

c. Divide one of the blasting cap leg wires and connect battery or other source of power.

d. Attach one blasting cap leg wire to the screw, making sure that the insulation of the wire is snubbed up close to the screw. Attach the other cap wire to the handle about the stem.

e. Connect the blasting cap to the main charge.

f. Make the necessary setting corrections to the watch, being careful not to cause contact between hand and screw.

5. Functioning

With the passage of time, the hand will ultimately contact the screw. This completes the electrical circuit and causes the blasting cap to detonate.

6. Disarming

   a. Detach blasting cap wires from the power source.

   b. Remove the cap from the main charge.

7. Longer Delay

A longer delay fuse may be fashioned through the use of two watches, as is shown in Fig. 143.

Watch No. 1	Watch No. 2
(1) Hand will move as long as watch continues to operate (normally about 24 hours).	(1) Hand will move for 11 hours.
(2) Has a wire installed so as to permit momentary contact of wire with watch hand. (Note: This wire must be flexible enough to permit the watch hand to pass, and should be positioned so that it rakes the top surface of the watch hand as the hand passes.)	(2) Has screw installed as previously described.

(Note: The maximum delay achievable with this system is 22 hours.)

Functioning of System: After 10 hours' operation, the hand of Watch No. 1 reaches, lifts, and passes the wire contact. After 11 hours' operation the hand of Watch No. 2 is halted by the screw. The hand of Watch No. 1 continues its movement and, after another 12 hours, again touches the wire contact--this completes the circuit and detonates the blasting cap.

CAUTION: It is necessary to have Watch No. 1 running ahead of Watch No. 2; otherwise the circuit would be completed the first time the hand of Watch No. 1 touched the wire contact.

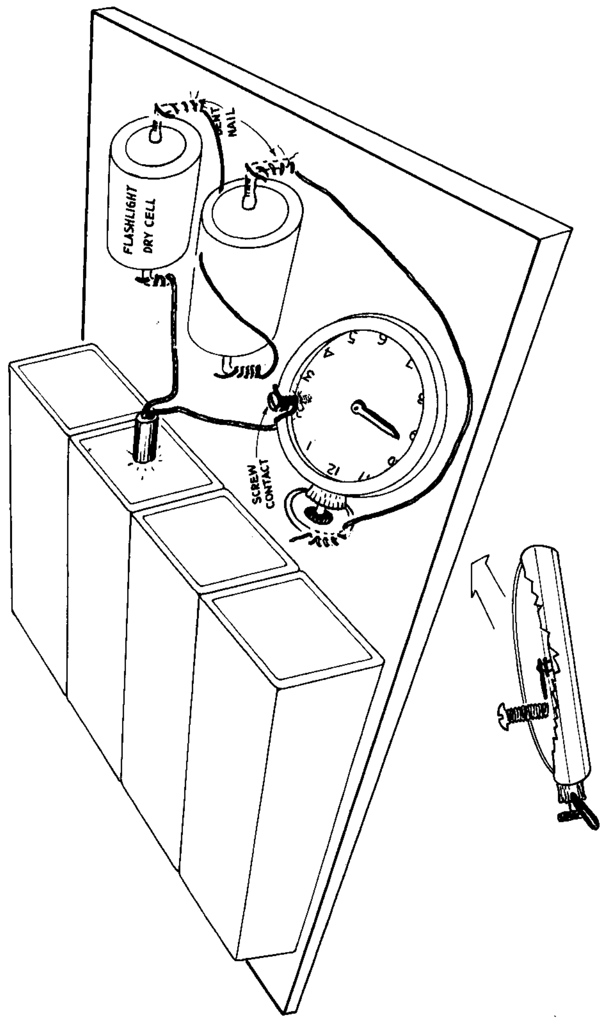


Figure 142

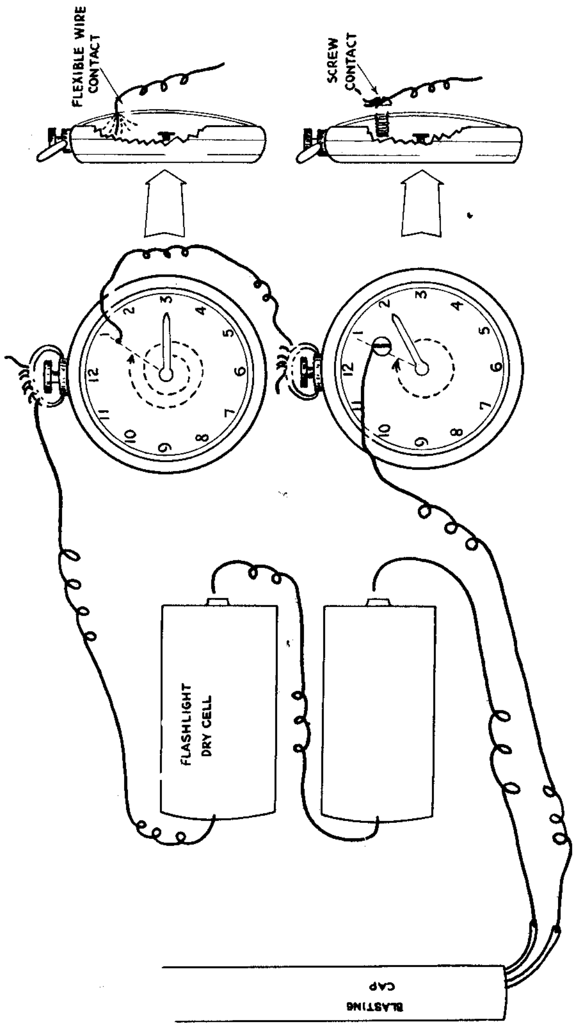


Figure 143

J. Mechanically Triggered Chemical Fuses (Fig. 144)

1. Uses

   a. Sabotage firing systems.

   b. Booby trap fuses.

   c. Improvised mine fuses.

2. Materials Required

   a. Chlorate-sugar mixture (see First Fire Mixtures, Section 4. C., Chapter III.).

   b. Sulfuric acid.

   c. Eye dropper, perfume vial, test tube, etc.

   d. Assorted boards, nails, etc.

3. Construction

   a. Pressure Fuse (Note: Other fuses--pull, release, etc., see Fig. 144--may be improvised to utilize this acid ignition principle.)

      (1) Construct a box to hold the desired amount of explosive. The top should be removable and should have a hole cut at the center to permit passage of the treadle pin.

      (2) The treadle should be about the size of the box top. The center mounted treadle pin should be long enough to touch the bottom of the box when the treadle and box are assembled.

4. Priming and Arming

   a. Fashion a simple nail clamp to hold the acid container in the proper position at the bottom of the box.

   b. Load the box with explosive, leaving the center vacant.

   c. Fill the glass container with sulfuric acid and stopper it.

   d. After ascertaining that the acid container is tightly stoppered, clamp it in position. (Note: The outside surfaces of the container must be free of acid.)

e. Pour a cupful of chlorate-sugar around (not on top of) the acid container.

f. Connect the detonating cord with tape to two or more blasting caps. Fill these caps with chlorate-sugar and then place the caps within the chlorate-sugar surrounding the acid container in such a way that flame will reach the open end of the cap before it reaches the detonating cord. The opposite ends of the detonating cord should be affixed to the main explosive charge.

g. Place the top on the box and carefully assemble the box and treadle. (<u>Note</u>: Through previous tests, it should have been ascertained that the weight of the treadle alone will not break the acid container.)

5. <u>Functioning</u>

When sufficient pressure is exerted on the treadle, the acid container is crushed and a hot flame results when the acid reaches the chlorate-sugar.

6. <u>Disarming</u>

Remove the treadle, box top, and acid container.

K. Acid Delay (Fig. 145)

1. <u>Use</u>

Used as a moderately accurate short-time delay fuse for sabotage operations.

2. <u>Materials Required</u>

a. Chlorate-sugar mixture (see First Fire Mixtures, Section 4. C., Chapter III.).

b. Sulfuric acid.

c. Gelatin capsules, rubber containers, or bottles with rubber membranes.

d. Assorted boards, nails, etc.

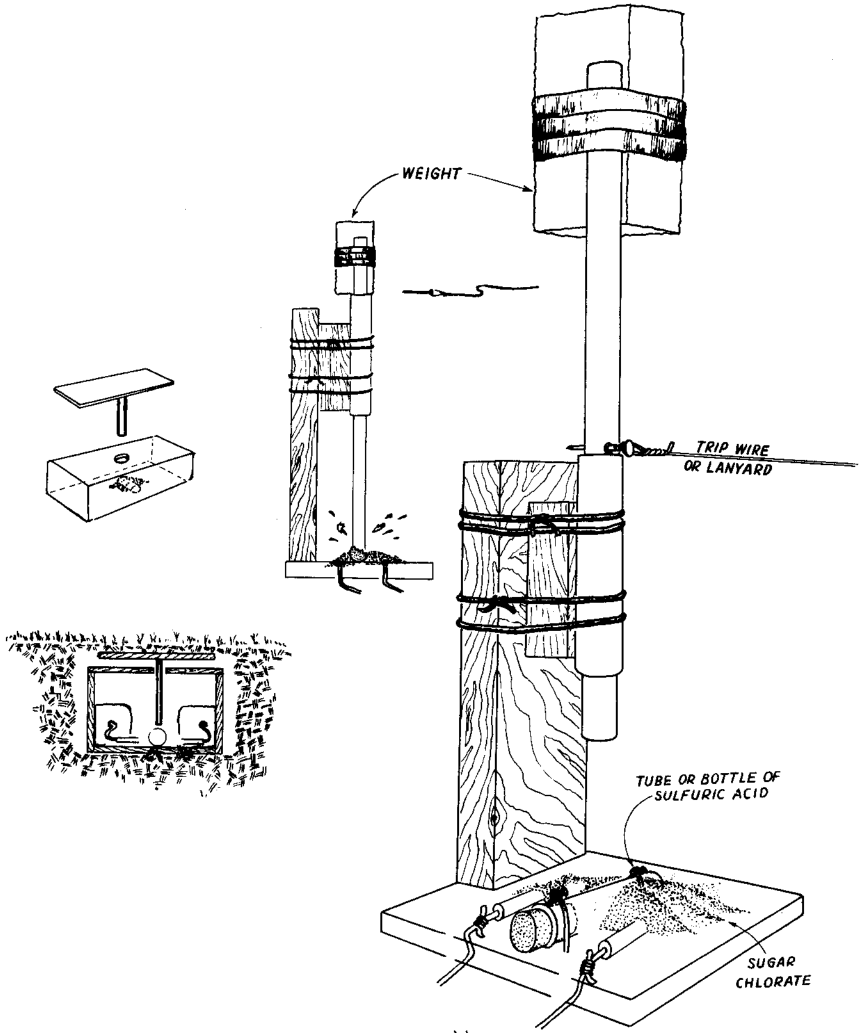


Figure 144

3. Construction

Construct a box to hold the desired amount of explosive or incendiary material. (Note: If the box is to hold incendiary material, provision should be made for venting products of combustion and for oxygen supply, if such is necessary; see Chapter III.)

4. Priming and Arming

a. Load the box with explosive or incendiary material, leaving an open space at the center for the priming mixture.

b. Pour a cupful or two of chlorate-sugar mixture into the priming pocket. (Note: If this is an explosive charge, connect the blasting caps and detonating cord and place as described for the Mechanically Triggered Chemical Fuses, paragraph J. of this Section.)

c. Pour the acid into a capsule or rubber container and seal the container.

(Note: The chemical reaction begins immediately. It is therefore important that this step take place just before the saboteur withdraws. The delay depends upon the concentration of the acid solution and the thickness of the gelatin or rubber involved. A single capsule containing a 60-percent solution of acid normally takes from 2 to 8 minutes at normal temperature. Longer delays result when the acid must dissolve two or more layers of gelatin. A single thickness of rubber normally gives a delay of from 15 to 30 minutes.)

d. After having ascertained that no acid is on the outer surface of the container, place the container on top of the chlorate-sugar mixture.

5. Functioning

The acid slowly dissolves the container and ultimately reaches the chlorate-sugar mixture, producing a hot flame.

6. Disarming

Once the chemical process has been initiated it is hazardous to attempt disarming. If the charge must be neutralized, the acid container should be separated from the chlorate-sugar mixture.

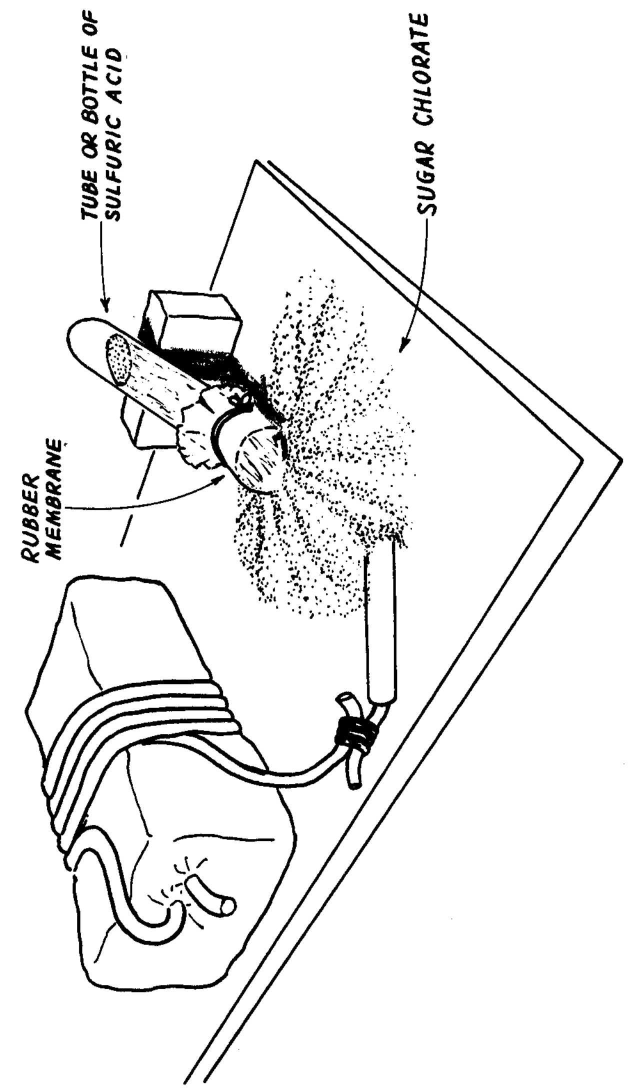


Figure 145

L. Cartridge Fuse (Fig. 146)

1. Uses

a. Lanyard-operated firing system for sabotage and guerrilla-warfare operations.

b. Booby trap fuse.

2. Materials Required

a. Military rifle cartridge.

b. Assorted lumber.

c. Assorted nails.

d. Tin can.

3. Tools Required

a. Hacksaw.

b. Tin snips or scissor.

c. Hammer.

4. Construction

a. Remove the projectile from the cartridge and pour out the propellant.

b. Saw through the cartridge case (see Fig. 146).

c. Affix the cartridge case at the proper position on the base board with two nails.

d. With a pair of tin snips or scissors, cut two 2-by-5-inch strips from a tin can. A door hinge can also be used for this purpose.

e. Bend the strips about the firing pin nail (see Fig. 146). Flatten the strips about the nail and secure in the proper position on the base board with nails. (Note: The firing pin must slide freely in the strip recess.)

f. Saw the hammer from a 2-by-4 type board, as is shown in Fig. 146.

g. Drill the trip-pin hole.

5. Priming and Arming

a. Remove the firing pin nail.

b. Place the fuse at the firing position by nailing the base board to a vertical surface.

c. Position a blasting cap within the cartridge case, with the open end directly against the primer opening. Place a detonating cord priming lead alongside the cap and secure both to the cartridge case with cord or tape.

d. Cock the fuse by lifting the hammer and inserting the trip pin equipped with trip wire or lanyard.

e. Connect the detonating cord priming lead to the main charge.

f. Insert the firing pin nail.

(Note: This fuse should be tested before it is used operationally.)

6. Functioning

When the lanyard is pulled the hammer is released and strikes the firing pin; the firing pin then strikes the cartridge, detonating the cap.

7. Disarming

Remove the blasting cap from the cartridge.

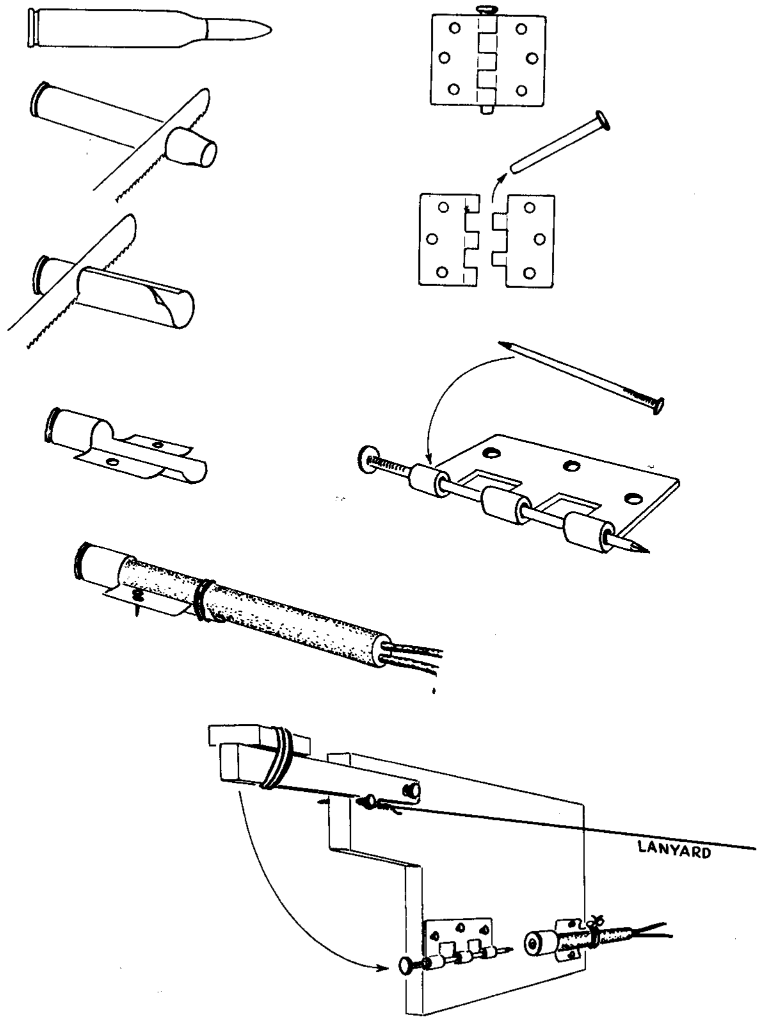


Figure 146

CHAPTER III. INCENDIARIES AND THEIR USES

SECTION 1. INTRODUCTION

A. General

Fire has always been one of the favorite tools of the saboteur. The means for starting fires exist everywhere, and the damage that follows hides, in many cases, the traces of sabotage.

Many of the past attempts at sabotage by fire, however, have met with complete or partial failure. These failures were attributable in part, at least, to ignorance of the principles, tools, and techniques of incendiary sabotage. The purpose of this Chapter is to provide the guidance necessary to increase the success ratio of incendiary sabotage.

B. Essentials of Combustion

Fire or combustion is dependent upon a combination of three essentials:

1. The presence of a flammable substance.

2. A supply of oxygen or air.

3. The proper degree of heat, and in some cases a spark or open flame.

So long as these requisites exist, a fire will be sustained. The denial of one or more of them means the end of the fire.

C. Causes of Fire

Fires occur intentionally or accidentally. In either case, the same conditions must be present. The most important element of fire is heat or a spark, because there is oxygen almost anywhere flammables may be found. In the majority of cases, heat gain is imparted to a flammable substance from an outside source such as steam pipes, cigarettes, electric sparks, etc. Such a source may or may not involve flame.

Self-ignition occurs in materials which are poor conductors of heat, such as tightly packed coal or green vegetation. Internal heat resulting from oxidation or bacterial activity builds up instead of being carried away, until finally the ignition temperature of the material is reached.

D. Convection and Radiation

The growth of fire involves two factors: convection and radiation. At the beginning of a fire, 85 percent of the heat is circulated or convected upward and 15 percent is radiated laterally. Later on, the spread of the fire by radiation becomes much more important than the spread by convection. It is important, therefore, to arrange combustibles or choose a place where combustibles are already arranged to receive the full effect of the upward and outward direction of the fire.

E. Dust and Vapor Explosions

Dust and vapor explosions are in reality fires, but since considerable force is associated with the combustion in these cases, the terms "dust explosion" or "vapor explosion" are used. Dust or vapor explosions occur when particles of a combustible dust or vapor are suspended in a dispersed state in air and are exposed to a source of heat sufficiently high in temperature to cause ignition. The particles must be close enough to each other to allow propagation of flame, and yet sufficiently separated to leave room for the necessary amount of oxygen for combustion. The materials usually associated with this type of explosion are flour, coal, and gasoline. Information on how to start these explosions is given later in this Chapter.

SECTION 2. INCENDIARISM

A. General

Incendiary sabotage is termed either subtle sabotage or direct sabotage, depending on whether or not an attempt is made to disguise the cause of fire and make it appear to have been the result of an accident. The tools, tactics, and techniques are markedly affected by the impression the saboteur seeks to create, and so the two types of attack are discussed separately in this Section.

B. Subtle Attack

In order to avoid reprisals from the enemy, a saboteur may seek to cause damage by setting "accidentally caused fires." The limitations imposed on such operations are many, and for this reason subtle actions are likely to be less effective than those of direct action. As long as "accidental fires" do not occur with regularity, the saboteur may have everything to gain and little to loose. It should be

remembered that the primary aim of a subtle action is successful disguise of fire cause, not maximum target damage--even though the latter is highly desirable.

In considering a subtle attack, the saboteur should consider each of the following:

1. Choice of Incendiary

Since the fire must appear from its inception to have been accidentally caused, the incendiary material should, if possible, be common to the target installation. This is not so unreasonable as it might sound, for oily waste or rags, lubricants, and cleaning solvents are common wherever machinery is found. If an installation does not supply the incendiary, then the saboteur should procure a substance that will provide the necessary heat without leaving a clinker or telltale ash. In keeping with the "accidental" nature of the fire, the delay mechanism should also be of combustible material.

The simultaneous outbreak of two or more widely separated fires is taboo. Subtle action requires that everything done be in keeping with the accident theory. Fires are a common occurrence in many industries. "Encourage" the conditions which start these fires, making their occurrence more frequent. Short circuits and dropped cigarette butts and matches are "accidents" which may be utilized to advantage. Floors and walls carry steam pipes and electrical conductors which may be employed with a minimum of arranging to supply the heat or spark necessary to cause ignition.

2. The Ignition Site

The ignition site refers to the physical surroundings in which an incendiary package is placed. Where possible the ignition site should be at the base of a vertical surface, in order to influence convection. If possible, an ignition site at the base of one of two close-set vertical surfaces such as a narrow corridor should be taken advantage of. Such a site favors radiation, which is advantageous to the rapid spread of fire.

A good ignition site is one which is located along the path of a slow-moving air stream and which takes advantage of natural ventilation. If such a site does not exist it may be possible to create one by opening a window or door.

In selection of an ignition site, the following materials should be avoided:

a. Painted surfaces. These burn very slowly. The flammable oils and solvents of paint evaporate during the drying process.

b. Wall-papered surfaces. These burn very slowly because the dried paste backing is not especially flammable.

c. Moist wood surfaces. Before wood will ignite, its moisture content must have evaporated.

d. Plastered surfaces. These are not combustible.

3. Time of Attack

Generally speaking, a fire has its best chance to reach an advanced stage if it is set during the night or during some other period of inactivity, when fewer people are around to see, report, and fight it. Of course, if the target substance is a volatile petroleum product or similar flammable, a fire might spread and reach a critical stage in a matter of seconds, so that timing might be a minor consideration. On the other hand, it might be advantageous or necessary to wait for an air raid, or for the proper wind condition, or until a warehouse is completely filled, etc.

4. Dust and Vapor Explosions

The presence of highly flammable dusts and/or vapors once posed a major threat in coal mines, metal industries, oil refineries, granaries, flour mills, sugar refineries, the pulp and paper industries, etc. However, modern industry's realistic approach to fire prevention has, to a large extent, removed the possibility of accidental dust explosions by adopting certain equipment and precautions such as dust catchers, forced draft ventilation, nonsparking electrical equipment, and skilled maintenance procedures.

The possibility of causing a dust explosion by tampering with equipment (e.g. removing machinery ground wire, causing electric switches to arc, etc.) to provide for the ignition of dust concentrations might certainly be done without violating the accident principle, but there is no certainty that such actions would bring about the desired effect. The only sure way of taking advantage of natural dust and vapor hazards is by direct means (see later Sections of this Chapter for further discussion of dust explosions).

C. Direct Attack

In the direct attack the saboteur's aim is maximum target damage rather than the creation of a false impression as to how the fire started. Accordingly, the tactics and techniques associated with direct sabotage are radically different from those of the subtle action.

1. Choice of Incendiary

The prepared incendiaries (see Section 3.) are generally desirable for direct action because of their burning characteristics. When these are not available, the saboteur should be able to compound reasonable substitutes from materials available to him (see Homemade Incendiaries, Section 4.).

2. The Ignition Site

There is no reason to localize the outbreak of fire when an operation is of the direct action type. The simultaneous ignition of several incendiaries placed in various key places within a target installation will accelerate a fire and thereby complicate efforts to combat it.

Paint lockers, chemical storage tanks, gas mains, bulk stocks of flammable solids, etc. warrant primary attention as possible ignition sites. It goes without saying, however, that unless this so-called natural hazard possesses or affords other advantages (such as proximity to critical equipment, unobstructed directional ventilation, or any other factor that influences or contributes to the desired effect) it cannot be considered an ideal ignition site.

The principle of heat convection dictates that ignition take place at the bottom of a target. In the case of buildings, it is best if the fires break out on the lower levels. Ideally, these should be near elevator shafts or stairways, which will serve to channel the resulting heat toward the upper levels and thereby accelerate the spread of the fire.

When a target does not afford the vertical surfaces necessary to promote radiation, the saboteur may improvise such surfaces with desks, chairs, doors, packing cases, etc. When possible, a flammable wall should constitute one of the vertical surfaces. The distance between the reflecting surfaces should be from 2 to 10 inches, depending on the size of the incendiary. Such arrangements promote combustion in that the maximum amount of an incendiary's heat energy is absorbed, thereby assuring more intense burning from the start.

Although heat promotes air circulation, obstructed corners and similar places should normally be avoided in favor of locations along natural or created air streams. Windows and doors should be opened where necessary to provide an oxygen supply. Although strong air currents are beneficial to the spread of fires which are beyond the ignition stage, such air currents tend to retard ignition because they have a cooling effect on gases and surfaces alike. Therefore, when strong winds are blowing it may be necessary to select the obstructed corner previously mentioned as an ignition site or to erect a temporary air shield with doors, furniture, etc.

Fires should always be started "up wind" so as to enfilade or engulf as much of the target as possible in heat and flame. This is especially true of outdoor fires, where the target may be a city, forest, ripened grain, a lumberyard, etc.

It is also well to consider where a fire should start in order to best thwart the attempts of fire fighters to put it out or control it. For example, if the target were a long wharf it would be best to start the fire at the land side on a day when the land side of the wharf was "up wind." The result of such an operation might completely stymie the efforts of land fire fighters to put it out.

3. Time of Attack

(See paragraph B. 3. of this Section.)

4. Countermeasures

In order to achieve maximum target damage in an incendiary attack, the fire fighting measures in an installation should be studied and, if possible, removed or neutralized.

Fire defenses take cognizance of fire hazards inherent in the type of structure and industrial process concerned, and therefore are not the same in every case. With respect to a planned fire, a saboteur should ask himself the following questions in order to determine the defenses of a particular target:

(1) How long will it be before the fire is discovered?

(2) How will the finder report it?

(3) What aid, personnel, and equipment will be immediately available?

(4) Who will respond?

(5) What route will they take to get to the fire?

Question(1) has to do with the guards or alarms, whose purpose is to alert fire brigades and to initiate immediate action to reduce or control the spread of the fire.

Guards or watchmen are maintained during periods of plant inactivity to patrol the premises in search of fire or other irregularities. To prevent evasion of duty by guards and watchmen, many plants are equipped with checker devices which are placed at various points throughout the facility and which, when operated by a watchman, make a lasting record of his movements. A saboteur might enlist the aid of a watchman or, barring this, might be forced to immobilize the individual in order that his objective be accomplished. If the target plant were equipped with checker devices, which were connected to a central control office, a member of the sabotage group should be acquainted with the patrolling routine and should take the place of the guard.

Electrically controlled thermal detecting alarms are arranged so that they sound an audible alarm and flash a visual signal in a central control office or a nearby fire department. Alarm systems generally operate on an auxiliary power system which runs on direct current. When confronted by this type of defense, the saboteur may have to consider the central control room, power source, and outside telephone lines as additional targets, unless "inside arrangements" are made to counter this system just prior to the operation.

Automatic sprinkler systems are very often equipped with audible and visual alarms and therefore warrant the saboteur's attention. A sprinkler system is an arrangement of pipes and valves which are mounted along the ceiling of a building and which automatically spray water whenever an outbreak of fire is detected by one or many of its sprinkler heads. The sprinkler heads normally function when the air temperature reaches 155° to 165° F.

In dealing with sprinkler systems, the saboteur should tamper with or damage the main control valves. Tampering should consist of (1) breaking the gate valve seal or chain, (2) turning the valve from the open to the closed position, and (3) securing the valve in this position with a lock and chain. Damaging should consist of (1) breaking the handwheel off the

valve gate post, and (2) bending the post to one side, after the valve has been moved from the open to the closed position. Usually, the alarm is arranged to function with the passage of water through the valve. It is, therefore, unnecessary to tamper with an alarm if the main control valve is made inoperable.

In considering sprinkler systems, one should not forget the damage that may be done by water alone. Especially susceptible to this form of attack are textile mills, chemical plants, and granaries. In such cases, several automatic sprinkler heads can be made to function by arranging an assembly similar to that shown in Fig. 147. In order that maximum damage result, it is advisable that the main control valve alarm be disconnected or otherwise made inoperable.

In petroleum refineries, certain chemical plants, electric power installations, and other places where water cannot be used, foam (a mixture of aluminum sulfate and bicarbonate of soda), carbon dioxide, steam, etc., are often conveyed throughout a plant by piping similar to the water sprinkler system. These systems are both automatic and manually operated and should be thoroughly investigated in order to determine whether or not they need be countered.

Question(2) refers to the device by which a guard or watchman alerts the fire-fighting and security forces. Generally speaking, this is a fire alarm box, telephone, siren, or other audible signal. Fire alarm boxes are generally on a closed circuit which terminates at a local fire department. They are manually operated, usually by movement of a throw-type switch. There are several types of box alarm systems in use today, one of which may be of particular interest to a saboteur. In this particular system, the alarm box has no ability to control its circuit once it has been operated; hence, if more than one box is used at or about the same time, a mixed, a confused, or a totally incomprehensible signal will result. Therefore, a saboteur should seek to find out whether or not the alarm system in his locality is of this type.

Mention has already been made of the severing of outgoing telephone trunk lines and immobilization of guard personnel.

Question(3) refers to the personnel (in addition to the individual who discovers the fire) who are immediately available and the equipment they will use to combat the flames. Many industries keep a skeleton force working during periods of

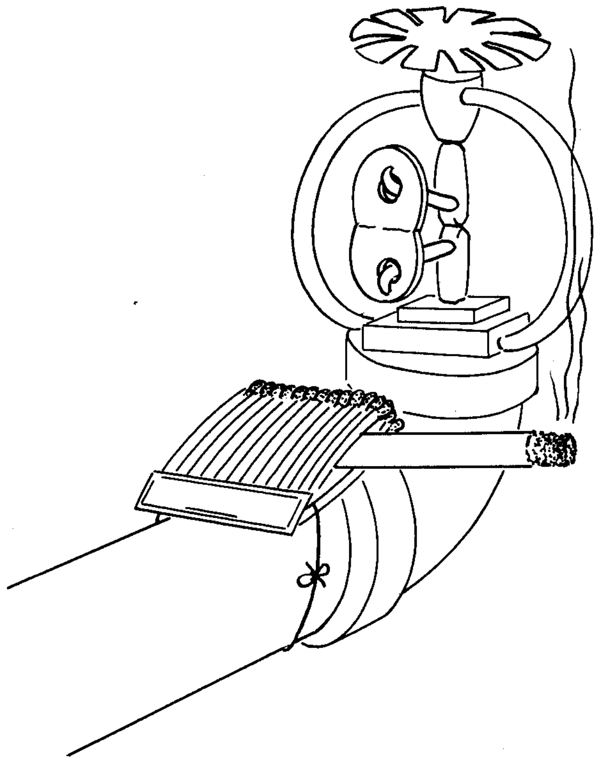


Figure 147

plant inactivity. These are mainly maintenance and janitorial personnel who wander about the installation in accordance with their general duties. To prevent their later interference with the fire they should, if possible, be rounded up beforehand and, if necessary, be forcibly restrained from taking any action that might detract from the success of the operation. If such action is not feasible, fragmentation grenades, etc. left in and around the burning area will discourage fire fighters.

Among the plant fire-fighting equipment to be immobilized are static sprinkler and foam systems (already mentioned), fire hoses, extinguishers, and fire doors. The hoses should be slashed and uncoupled and detached from the hydrants. The threads of hydrants should be flattened and the valve shafts bent. Extinguishers should be emptied or hoses plugged. When the latter is done to soda-acid extinguishers they may explode when inverted. Automatic fire doors should be blocked open, so that they cannot be be used.

Question (4) refers to the organized fire-fighting force that would respond to an alarm from the target. In order to plan his counteraction, the saboteur would be interested in knowing what forces exist and from where they would come.

Secondary fire actions may divert all or part of a fire-fighting force from the primary target for the time it takes the fire to reach an advanced stage. Such diversions should be as far away from the main target as possible, without being outside the jurisdiction of the fire-fighting force.

Question (5) deals with the actual streets or roads that a fire brigade would in all probability use in traveling from the fire house to the target. If possible, these should be blocked by felling trees, or at least made generally impassable by dispersing road nails or tire bursters on the road surfaces.

5. Dust and Vapor Explosions

A dust or vapor explosion can be induced by detonating a charge of explosive mixed with incendiary material in either a container of highly volatile flammable liquid or in a bed of flammable dust. Upon detonation of the explosive, a cloud of vapor or dust is dispersed in the surrounding atmosphere. When the ratio of oxygen to vapor or dust reaches the explosive range, the incendiary ignites the cloud (for details on this, see Diffuser Igniters, Sections 3. D. and 4. E.).

SECTION 3. PREPARED INCENDIARIES

A. General

Prepared incendiaries are those manufactured fire-producing devices which are issued to field forces. They generally incorporate a firing system or fuse with the incendiary substance in one unit.

The available prepared incendiaries are discussed by class--thermite, fire starters, and diffuser igniters--in the following paragraphs.

B. Thermite

1. General

Thermite is a mixture of finely divided aluminum powder and iron oxide (Fe_2O_3) or magnetic iron oxide (Fe_3O_4) (the latter is preferred). When reaction is initiated by strong heat (about 2800°F) the aluminum powder is used to reduce iron oxide to free iron by direct oxidation of aluminum to aluminum oxide. The reaction may take place in the absence of air, so that attempts to extinguish its flames by smothering techniques are ineffective. The heat of reaction is so intense (4200-4900°F) that it will melt iron and steel. The process has been used industrially for many years--principally to butt-weld rail ends. In sabotage, it may be used to weld machinery parts together and to ignite combustibles. The disadvantage associated with the use of thermite is the characteristic residue or clinker that remains after the reaction is complete. This is of iron and aluminum oxide and is easily identified by laboratory analysis. Thermite cannot be directly ignited with safety fuse or match. It therefore is necessary to use a first fire mixture. (Note: A first fire mixture is a chemical substance that will take flame from a match and develop sufficient heat to cause ignition of thermite or some other bulk incendiary. First fire mixtures are described in Section 4. of this Chapter.)

2. Thermit Well (Fig. 148)

a. Characteristics

(1) Container	Ceramic liner covered with waterproof pasteboard. The ends are sheet metal. The top is provided with a friction-type lid. The unit is packaged in foil or barrier material.

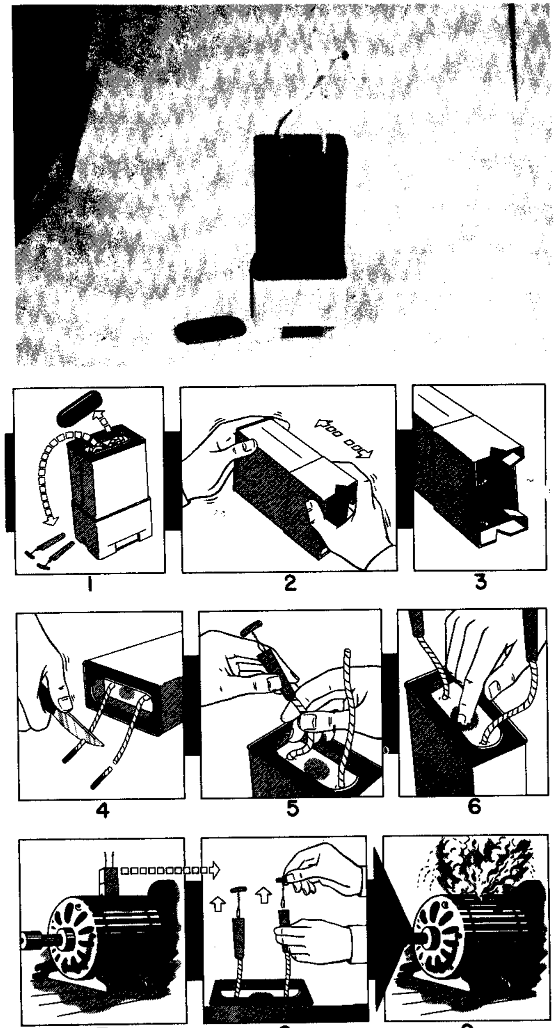


Figure 148

(2)	Total Weight	4 pounds.
(3)	Incendiary Mixture	37 ounces of Thermit.
(4)	Ignition System	Dual, 20-second safety fuse with friction-type fuse lighter.
(5)	Ignition Mixture	$8\frac{1}{2}$ grams (atomized aluminum, iron oxide, and barium peroxide).
(6)	Burning Temperature	4600° F.
(7)	Burning Time	Approximately 1 minute.
(8)	Performance Effect	Will penetrate 3/4 of an inch of steel.

b. Purpose

The Thermit Well is used to attack metallic targets, such as transformers, electric motors, gears, bearings, boilers, storage tanks, and pipelines. In operation, the device produces a quantity of molten metal that streams out the bottom of the unit. On contact with the target the molten metal will cut through the casing and pour molten metal on some vital part. Steel casings up to 20 millimeters (three quarters of an inch) thick can be cut in this manner.

c. Operation

(1) Pry the tin lid off the unit and remove the two pull-type fuse lighters that are packed in the compartment at the top of the container.

(2) Slide the cardboard sleeve partway down on the container.

(3) Bend the tabs inward. These tabs keep the container raised at the correct standoff distance from the target.

(4) Straighten the two pieces of fuse in the compartment so that the fuses extend out of the container. Cut off the tips of the fuse to expose the inner powder train.

(5) Insert each fuse into the open ends of the pull-type fuse lighters and make sure they are tight.

(6) Pierce the paper seal at the top of the container.

(7) Stand the Thermit Well on the target in an upright position that will cause the stream of molten metal to contact a vital part.

(8) Grasp the body of the pull-type lighter in one hand and pull the pull-tab out with the other hand. Do this to both fuses so that the unit is certain to burn. There is a delay period of about 1 minute before the fuses ignite the device.

(9) After 1 minute, there may be some sputtering and boiling at the top of the device while the molten metal is being produced. When the molten metal flows onto the target, however, there is a fiery reaction that may even be mildly explosive.

d. Result

The molten metal damages the target by cutting a hole through it and pouring molten metal on vital parts. There is also an incendiary effect when the target contains flammable liquids, or is a cover over flammable material.

e. Uses

(1) Against Steel

The Thermit Well was designed for use against machinery and metal objects such as gear boxes, bearing pedestals, electric motors and generators, large telephone cables, etc.

The Well should not be placed on steel objects that are more than three-quarters of an inch thick.

Performance is best if the target surface is dry and clean.

Inclined surfaces should be avoided if possible, since the molten stream will tend to flow toward the lower level.

(Note: The burning of the standoff sleeve poses no threat to the performance of the charge, since the Thermit reaction will have been completed before the sleeve takes flame.)

(2) Against Solid Flammables

The Thermit Well should be placed on dry timber which is at least 2 inches thick. Vertical baffles should be

fashioned on either side of the container. This "trough" should be placed close to another flammable, vertical surface (wall, crates, etc.) so as to favor convection. The trough may be tilted slightly to aid the dispersion of the molten metal over a larger surface. Kindling (box wood, oily rags, etc.) will add to the effect.

(3) Against Liquid Flammables

The Thermit Well should not be placed on top of tanks and storage drums containing volatile flammables (gasoline, fuel oil, etc.). This action produces very limited damage, i.e., a small hole and a burning jet of gaseous vapors which is easily extinguished. Instead, fashion a trough of metal or wood to direct the molten flow to the bottom of such tanks or drums. This is effective only against thin-gauge (less than one-eighth inch) containers. This is because of the angle at which the molten mass flows onto the target and because of the convection currents within the liquid which serve to cool the heated area of the container (see Section 5. A. for other methods of attacking petroleum storage).

f. Other Firing Systems

Other firing systems (time pencils, safety fuse) may be attached to the Thermit Well's fuses if a longer delay is desired.

3. Incendiary Grenade, AN-M14 (Fig. 149)

a. Characteristics

(1)	Container	Sheet metal.
(2)	Total Weight	2 pounds.
(3)	Incendiary Mixture	26 ounces of thermite.
(4)	Ignition System	Bouchon-type Fuse M201 (2-second delays with igniter cup).
(5)	Ignition Mixture	A few grains of first fire mixture (mainly barium nitrate and aluminum).
(6)	Burning Temperature	4300° F.

(7) **Burning Time** — 30 to 45 seconds.

(8) Identification — Gray container with purple band.

(9) Performance Effect — Will penetrate one-quarter of an inch of steel.

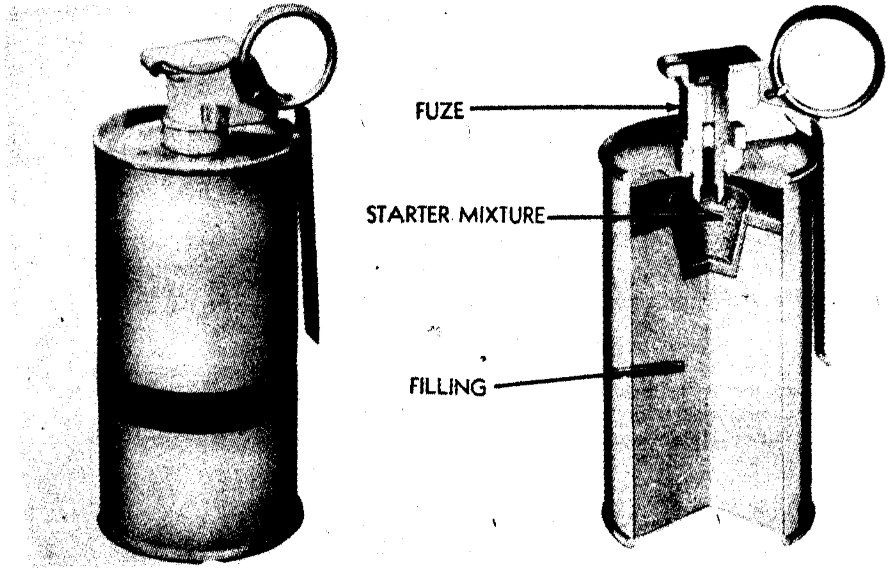


Figure 149

b. Functioning

The firing system consists of percussion cap, fuse, and squib-type igniter. The flame from the igniter lights the ignition mixture, which generates sufficient heat to start the thermite reaction. The grenade burns from the top, and since there is no ceramic liner to contain the molten metal it melts the sheet steel container and flows over the sides and onto the target. Because the molten metal is permitted to run off as it is being produced (instead of being contained until the reaction is complete) and because it is dispersed over a wide area rather than concentrated at one point, the grenade is much less effective than the Thermit Well. Burning residue consists of fragments of the container and fuse assembly and the metallic slag.

c. Firing Technique

(1) The grenade should be grasped in the placing or throwing hand, with the palm over the safety handle.

(2) Pull the safety pin with the free hand.

(3) Either throw the grenade or place it on the target and release it. In either case, the striker spring rotates the striker onto a percussion cap and throws the handle clear. After about 2 seconds, smoke and flame will issue from the fuse end of the grenade. The immediate flame is not so intense that it makes hand placement hazardous.

d. Uses

(1) Against Steel

The incendiary grenade was designed primarily for damaging or destroying artillery pieces, small machinery, ammunition, and other flammables that must be abandoned to an enemy.

The grenade should not be placed on steel objects that are more than one-quarter inch thick.

Performance is best if the target surface is dry and clean.

This charge may be placed either on its side or on end. (The flow of molten metal may be directed somewhat better if the grenade is placed on its side.)

To prevent dispersal of the molten metal, a clay or earthen dike should be fashioned to contain it.

(2) Use as a Grenade

To ignite flammables such as dry bushes, hay, etc., the grenade may be thrown. The throw should be a short, underhand toss to prevent the landing shock from tearing the grenade apart, which might cause a misfire.

(3) Against Other Targets

(Same as for Thermit Well.)

e. Other Firing Systems

Delay firing systems (time pencil, safety fuse, etc.) may be substituted for the standard fuse assembly with which the grenade is equipped. To assure ignition with such improvisations it is necessary to provide a source of heat to replace the squib-type igniter that has been removed. About an ounce of either of the homemade first fire mixtures (see Section 4. C.) should be poured into the grenade's fuse opening before the new firing system is attached.

Grenades should be disassembled in the following manner:

(1) Without removing the safety pin, bend the safety lever upward, as is shown in Fig. 150. This will permit greater leverage for unscrewing by hand.

(2) Grip the adapter with a thin-nosed plier, to prevent it from turning while the fuse is unscrewed.

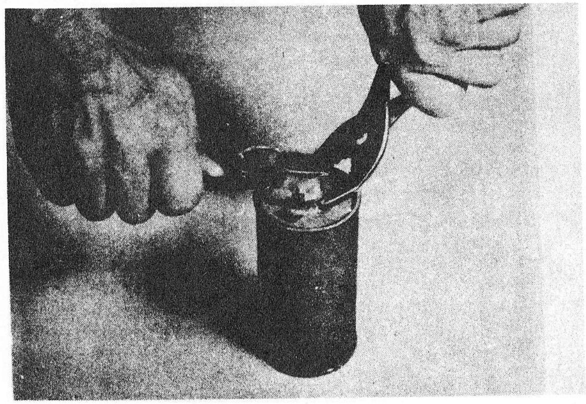


Figure 150. Removing Fuse from Grenade

C. Fire Starters

1. Pocket Time Incendiary (Fig. 151)

a. Characteristics

(1)	Container	Cellulose Nitrate.
(2)	Total Weight	9 ounces.

(3)	Incendiary Mixture	About 10 grams of napalm thickener mixed in approximately 1/3 pound of Stoddard Solvent (similar to gasoline).
(4)	Ignition System	Dual, modified time pencils, M1 with magnesium head.
(5)	Ignition Mixture	Magnesium with friction-type match head.
(6)	Burning Temperature	2500°.
(7)	Burning Time	10 to 15 minutes.

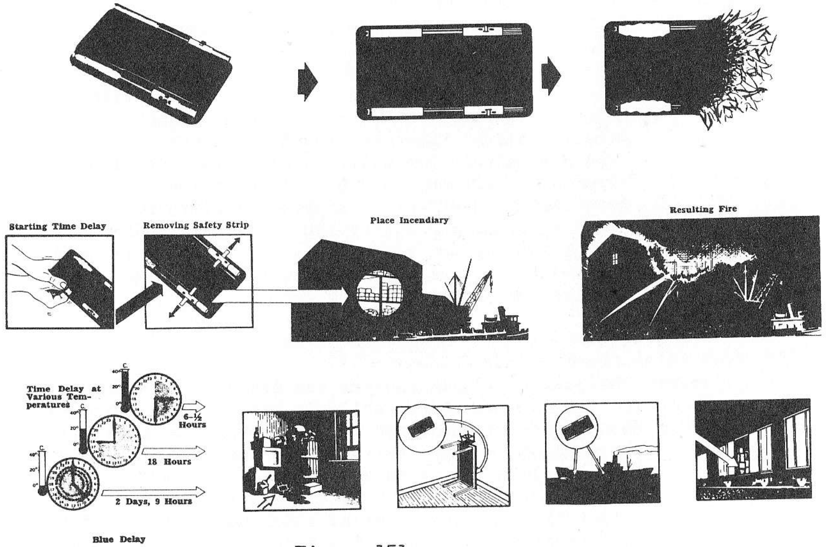


Figure 151

b. Instructions in the Arming and Use of the Pocket Time Incendiary

(1) Purpose:

This is a delayed-action incendiary. After its two time pencils are properly armed, the incendiary should be placed in or on a flammable target where it can start a huge fire.

(2) Arming the Time Delay:

Do this only at the place where the fire is to start:

(a) Crush the copper ends of the two time pencils on on the incendiary. This breaks the glass ampoules filled with chemicals and starts the time delay. (The clock faces and thermometers in the illustration are used to demonstrate the time-delay variation due to temperature. This is extremely important!)

CAUTION: Once the copper ends of the time pencils are crushed the time delay starts, even though the colored safety strips have not been removed.

(b) Pull out the colored safety strip in each time pencil.

(c) Place the incendiary among some highly combustible materials such as waste, a table and chair, or other kindling. Whenever possible, place the incendiary between two slightly separated, vertical flammable surfaces, thus providing airspace for more rapid and effective combustion. Provide a draft by opening a nearby door or window. When an oil dump is the target and a pool of oil is used as kindling, place the incendiary at the edge of the pool so that it will not be submerged.

(d) Use

The pocket time incendiary was designed as a delayed-action fire starter. While it develops and sustains moderately high temperature for several minutes, it should not be expected to ignite formidable targets (heavy planking, green wood, etc.) by itself. It is far more effective if it is nestled amid considerable kindling material which has been placed to influence the spread of the fire. If immediate ignition is desired, apply a match directly to the case or loosen the restraining wire screw of one of the time pencils after the safety strip has been withdrawn. This latter action causes instantaneous firing of the device, and the operator should be prepared to drop it or move away from it quickly. Unused time pencils should be removed from the device and retained.

2. White Phosphorus

a. General

White phosphorus is a solid that ignites spontaneously in air at temperatures above 93° F. It is used principally as a military smoke agent and antipersonnel munition. It is sealed in shell- and grenade-type casings which incorporate fuse-actuated bursting charges. Small particles or pellets of the phosphorus are therefore scattered in all directions when the container or casing is ruptured. The heat imparted to the phosphorus by the bursting charge is sufficient to bring the material to its automatic ignition temperature. The heat of combustion is moderate and is sufficient to ignite dry grass, brush, fabrics, and gasoline-type petroleum products. It will not ignite wooden planks or heavy fuel and lubricating oils consistently. It will cause severe skin burns. It is extinguished when isolated from a source of oxygen, so that water, carbon dioxide, sand and earth may be used to put it out.

b. Smoke Grenade, W.P., M15 (Fig. 152)

(1) Characteristics

(a)	Container	Sheet steel.
(b)	Total Weight	31 ounces.
(c)	Incendiary Mixture	White phosphorus.
(d)	Ignition System	Bouchon-type M6A4D fuse ($4\frac{1}{2}$-second delay with PETN-lead azide burster).
(e)	Burning Time	Particles burn for about 1 minute.
(f)	Identification	Gray container with yellow band.
(g)	Performance Effect	Scatters burning phosphorus particles.
(h)	Bursting Radius	20 yards.

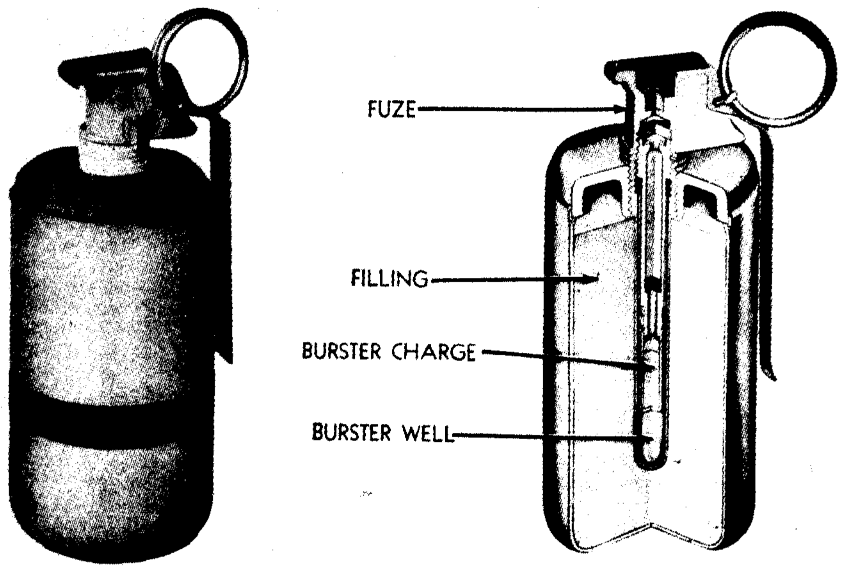


Figure 152

(2) Functioning

The firing system consists of percussion cap, fuse, and burster. The burster is powerful enough to shatter the container and strew phosphorus particles over a wide area. The burned residue of phosphorus particles are so small and widely scattered that they may be discounted, but the fuse assembly and case fragments serve to indicate the device used.

(3) Firing Technique

To fire, hold the fuse lever firmly against the grenade body with the throwing hand, remove the safety pin, and throw the grenade. The instant the grenade leaves the thrower's hand, the fuse lever is released and the fuse begins to function. The delay is about $4\frac{1}{2}$ seconds.

(4) Uses

The white phosphorus grenade is primarily a smoke grenade, but it is also used for antipersonnel and incendiary

purposes. It is ideal for starting dry brush and grain fires. See Section 5. A. for methods of attacking petroleum storage.

(5) Other Firing Systems

(a) Other firing systems (time pencils, time fuse, etc.) may be substituted for the standard fuse with which the grenade is equipped.

(6) Grenade Disassembly

(a) Without removing the safety pin, bend the safety lever upward, as is shown in Fig. 150.

(b) Grip the threaded portion of the burster well (which protrudes from the top of the grenade) with a thin-nosed plier to prevent the burster well from turning while the fuse is unscrewed manually.

CAUTION: The burster well/case seal should not be broken, as this may permit air to reach the white phosphorus.

(c) To replace the standard burster that is removed as part of the fuse assembly, tamp a few grams of plastic or granular explosive at the bottom of the grenade's fuse recess. The substitute firing system must incorporate a Special blasting cap that must be positioned so as to be in intimate contact with the explosive wad at the base of grenade's fuse recess.

D. Diffuser Igniters

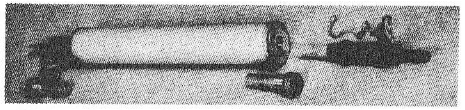
1. General

A diffuser igniter is not an incendiary in the true sense of the word, in that its major component is explosive. However, since the results attained through proper use of the device are incendiary in nature the diffuser igniter is classed as an incendiary.

2. Dispersed Combustible Initiator (Fig. 153)

a. Characteristics

(1) Container	Aluminum tube, 2 by 12 inches, with threaded end cap. The caps are recessed and threaded to hold shipping plugs, which are removed when the device is primed.
(2) Total Weight	2 pounds.
(3) Explosive-Incendiary Mixture	360 grams (60% granular TNT; 40% magnesium powder).
(4) Ignition System	A.C. Delay Fuse with M-34 detonator.
(5) Performance Effect	Causes flash fires of flammable dusts and vapors.



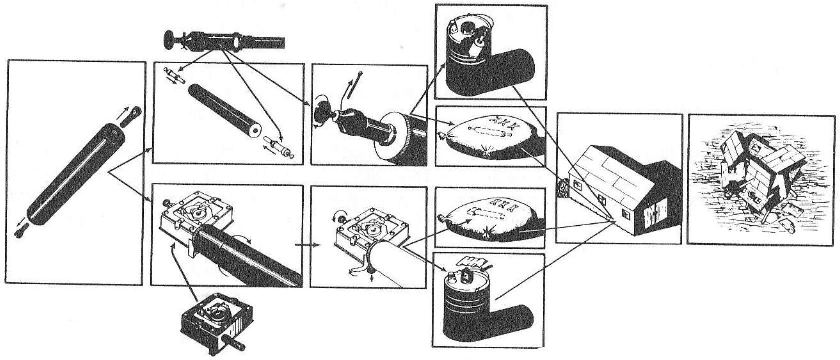


Figure 153

b. Functioning

(1) Purpose

This device is designed for blowing up targets (such as boxcars, warehouses, ship's holds, or factory buildings) which have confined spaces and limited ventilation openings.

(2) Installation Procedure

The initiator may be fired by a properly armed A.C. Delay or Clockwork, Firing Device, the assembly instructions for which are explained on instruction sheets enclosed with the respective devices.

The initiator, after unpacking, is assembled for use by first removing the shipping plugs at each end and discarding them.

Two A.C. Delay Firing Devices assembled with proper ampoules and detonators attached, are inserted into each end of the initiator in place of the two shipping plugs. Also, the Clockwork Firing Device may be used in one end of the initiator. Screw the firing device down tight.

The arming pin of the A.C. Delay is removed and discarded and the thumbscrew is turned into the delay body until the ampoule is crushed. Then turn the thumbscrew three full turns in the opposite direction.

The initiator thus armed may be inserted into a 25 to 100 pound bag of flour or a 10-gallon can of gasoline. When other highly combustible liquids or easily dispersible combustible powders are to be used with the initiator, the specific material should first be trial tested against a structure similar to the intended target.

SECTION 4. HOMEMADE INCENDIARIES

A. General

When prepared incendiaries are not available or when their use is not advisable, the saboteur may have to depend upon a homemade incendiary compounded from the most suitable materials available to him at the time.

Among the variety of incendiary mixtures, there are some that require expert handling and, because of certain mixing hazards, certain special laboratory equipment; still others require one or more specialized chemicals (substances which are not commonly available in quantity). So far as possible, these highly specialized types of homemade incendiaries have been omitted from this Handbook because of the general, all-around suitability of common, comparatively safe flammables such as gasoline, kerosene, tar, paint, wax, wood, gunpowder, etc. Most of these items are easy to ignite and if they do not develop high burning temperatures themselves they may be used to ignite kindling materials that do.

Homemade incendiaries may be classed as: thermite, first fire mixtures, fire starters, and diffuser igniters.

B. Thermite Incendiary

1. Materials Required

a. Magnetic iron oxide (iron rust or hammer scale--the bluish scale covering of iron pigs).

b. Aluminum powder (may be filings).

c. Potassium permanganate.

d. Wax.

e. Tin can.

f. Cardboard.

2. Preparation

a. Grind the iron oxide into a fine powder.

b. Pour equal volumes of the oxide and aluminum powder on a large sheet of paper and mix thoroughly. Mix the amounts with reference to the size of the can being used.

c. Line the vertical surfaces of the can with cardboard.

d. With a spoon, carefully ladle the thermite into the can (to within an inch from the top). The thermite should not be poured into the can because the heavier oxide granules would float the aluminum powder, thereby making the charge completely useless.

e. Without subjecting the can or the thermite in it to percussive shock, tamp the mixture by pressing it with a tamper rod. (The rod's cross sectional area should approximate the inner diameter of the cardboard sleeve.)

f. Prepare the first fire mixture by mixing two parts of potassium permanganate with one part of fine aluminum powder (only about 4 tablespoonfuls of the mixture are required). (Note: Other homemade first fire mixtures--chlorate-sugar and gunpowder-aluminum--will not consistently ignite thermite.) Wrap this mixture in a thin piece of paper so as to form a tight packet.

g. Make a small hole at the center of the thermite surface and insert the fire mixture packet into it.

h. Seal the top of the container by pouring molten paraffin wax over it so that a one-quarter inch seal results. The fire mixture packet should be coated but not covered. (Note: Although the incendiary has been tamped and sealed it must still be handled carefully so as not to disturb the contents.)

3. Priming

The incendiary may be ignited with a length of safety fuse. The end associated with the first fire mixture should be split and should contain one or more matchheads. The ignition packet should be punched through and the split end of the fuse inserted so as to be in contact with the first fire mixture. A time pencil may be affixed to the igniter fuse if long delays are necessary. The charge may be ignited without puncturing the wax seal by pouring a small quantity of a homemade fire mixture on top of the wax-coated ignition packet. This in turn may be initiated by flame, electricity, or acid, depending upon the fire mixture used.

4. Uses

(See Section 3. B. 2. e.)

C. First Fire Mixtures

1. Chlorate-Sugar Mixture

Chlorate-sugar is one of the best of the first fire mixtures. It is readily ignited by the flame from a match, the spit of a percussion cap or safety fuse, the heat of an incandescent wire with which it is in contact, or upon contact with sulfuric acid.

a. Materials Required

(1) Potassium chlorate (preferred) or sodium chlorate.

(2) Sugar.

b. Preparation

(1) Grind the chlorate so that the resulting granules approximate those of ordinary table sugar. Use a clean, nonsparking (glass or wooden) bowl as a mortar and a wooden stick as a pestle.

(2) Mix equal volumes of the granulated chlorate and sugar by placing both on a large sheet of paper and then lifting the corners alternately.

CAUTION: This mixture is extremely spark-sensitive and must be handled accordingly.

(3) Wrap the mixture (4 to 6 tablespoonfuls is usually sufficient to initiate the bulk incendiary) in thin paper so as to form a tight packet.

(4) Coat the packet with paraffin wax.

(Note: The sodium mixture is more hygroscopic than the potassium mixture. Chlorate-sugar should not be stored for longer than a day or two.)

Chlorate-sugar should not be ignited when under confinement, since it will explode. If contained in a waxed packet, the latter should be punched through in several places before it is attached to an incendiary. Chlorate-sugar burns rapidly, with a yellow-white flame. It generates sufficient heat to ignite all homemade incendiaries mentioned in this Handbook with the exception of thermite.

c. Priming

This mixture can be ignited by match, safety fuse, blasting cap, incandescent wire, or sulfuric acid.

2. Gunpowder-Aluminum Mixture

a. Materials Required

Several rounds of large-caliber rifle or pistol ammunition and aluminum powder.

b. Preparation

(1) Remove the projectiles from the bullets and pour out the gunpowder.

(2) Mix equal volumes of gunpowder with aluminum powder. The purpose of the use of the aluminum is to separate the granules of gunpowder, which otherwise would burn in one flash. Also, the aluminum retains the heat generated by the gunpowder.

(3) Wrap the mixture (4 to 6 tablespoonfuls is usually sufficient to initiate the homemade incendiaries discussed in this Handbook, with the exception of thermite) in thin paper so as to form a tight packet.

Before attaching it to the firing system, punch several holes in the packet to permit venting of products of combustion.

c. Priming

This mixture can be ignited by match, blasting cap, safety fuse, or incandescent wire.

D. Fire Starters

1. Napalm Incendiary

The burning characteristics of homemade napalm are generally comparable to those of the pocket time incendiary (PTI).

a. Materials Required

(1) Gasoline, kerosene, or a 50-50 mixture of both. (Burning gasoline develops a higher temperature than kerosene but it also burns faster; therefore, a mixture of the two makes a better incendiary.)

(2) Soap (not detergent).

b. Tools Required

(1) Portable charcoal stove or similar type stove.

(2) 1-to-5-gallon mixing can with handle.

c. Preparation

CAUTION: Napalm should be prepared out of doors and in areas free of dry grass, brush, etc.

(1) Burn sufficient wood, charcoal, coal, etc., until a good bed of glowing embers results. If possible cover the stove with a thin piece of sheet metal.

(2) Put about an inch of water in the mixing can, place the can on the stove and allow the water to come to a boil.

(3) Granulate or slice the soap so that small particles or chips result.

(4) Stir the water and add small quantities of soap to the water while stirring. Continue the process until the soap is completely dissolved and a pasty liquid results.

(5) While stirring, add small amounts of the gasoline-kerosene mixture. The temperature of the mixture should not be allowed to cool. Continue this process until the mixture assumes the desired consistency. The volume ratio of gasoline to soap varies between 10 to 1 and 20 to 1.

CAUTION: Never attempt to heat gasoline, etc. over a flaming fire--the flames will ignite the vapors. Since ignition is likely to result under even the most favorable of conditions, the mixer should provide himself with a piece of tin or board that will completely cover the mixing container. A mixing-can fire is easily extinguished by placing such a cover over the can.

(6) Remove the mixture from the fire and allow it to cool. Cooling will tend to thicken the gel.

(7) Package the napalm mixture in a cigar box-type container or in prepared rubber sleeves cut from automobile tire inner tubes, etc.

d. Priming

Any of the first fire mixtures described previously assures consistent and rapid ignition of napalm. The ignition packet should not be placed on the napalm until just before ignition, since the petroleum may dissolve the wax and soak into the first fire mixture.

2. Sawdust Incendiary

The burning characteristics of sawdust incendiaries are generally comparable to those of the prepared pocket time incendiary.

a. Materials Required

(1) Dry sawdust

(2) Tar or paraffin wax

b. Tools Required

(1) A portable charcoal stove or similar type stove.

(2) A 1-gallon mixing can with handle.

c. Preparation

CAUTION: Sawdust incendiaries should be prepared out-of-doors.

(1) Place the mixing can containing the desired amount of tar or wax over a bed of hot coals. Avoid open flame when using tar.

(2) When the contents of the can are completely molten, stir in an equal volume of sawdust.

(3) Pour the mixture into a small cardboard or wooden box and permit it to cool.

d. Priming

A first fire mixture is necessary for consistent ignition of sawdust incendiaries. The ignition packet may be fixed to the incendiary by joining the two before the wax or tar has solidified.

3. Miscellaneous Fire Starters

a. Gasoline

Whenever possible, gasoline should be diluted with kerosene or oil in order to slow the evaporation rate and thereby increase the burning time. The mixture should be poured over rags, cotton waste, sawdust, etc. rather than on bare floors or other flat surfaces. The ignition system should include a first fire packet.

b. Explosives

Small quantities (up to 1 pound) of Compositions C-3 and C-4 and TNT may be used to ignite kindling such as wood, oily rags, etc. Because they might cause the explosive to burn up rather than explode, first fire mixtures should not be used to ignite explosives.

c. Paints

Most paints contain hydrocarbons such as turpentine, hydrogenated naphthalene, or some other nonvolatile petroleum fraction. They are therefore highly flammable and should be dispersed on absorbent materials. Ignition systems should include a first fire mixture.

E. Diffuser Igniters

1. Homemade Diffuser Igniter

a. Materials Required

(1) Explosive (TNT preferred).

(2) Aluminum or magnesium powder or filings.

b. Preparation

(1) Granulate the explosive by pounding it with some non-sparking instrument.

CAUTION: Explosive dusts are toxic and should not be inhaled or allowed to settle on the skin. Keep the arms covered when granulating the explosive.

(2) Mix equal volumes of explosive and metal powder.

(3) Pour the mixture into a paper, cardboard, glass, or tin container.

(Note: To duplicate the performance of the prepared diffuser igniter, about 1 pound of explosive should be used with a like volume of metal powder.)

The contents of prepared fusion agents may be substituted for metallic powders, although the latter are preferred.

c. Priming

(1) This charge should be primed with a firing system that includes a triple-roll priming knot of detonating cord (see Section 7.B.1.c. of Chapter I.) or about an ounce of C-3 or C-4 explosive.

d. Uses

(See Section 3.D.)

SECTION 5. ATTACKING SPECIALIZED TARGETS

A. Petroleum Storage*

1. Dump Storage

a. Types

Dump storage consists of stacked drums or cans of gasoline, jet fuel, lubricants, etc. Large dumps may consist of several widely dispersed stacks of several hundred containers each. To select the proper incendiary, the saboteur should know what the stored petroleum product is.

b. Gasoline

Several small (1-pound) diffuser igniter charges should be affixed to drums at the base of the stack. Upon detonation, the drums to which charges have been affixed will be ruptured and their contents ignited by the hot, metallic components of

* This subject will also be treated under "Chemical and Allied Industries" in Vol. III, to be published at a future date.

the charge. All charges should be placed on the high side of the stack so that drainage will be into, instead of away from, the stack. The heat generated by the burning gasoline will be sufficient to vaporize the contents of nearby containers and thereby cause them to explode.

(Note: Never depend on the heat of the explosion to ignite gasoline vapors. Although this very often happens, especially when the atmospheric temperature is above 90° F, it is not certain to occur. If diffuser igniter charges cannot be prepared, use fire starter incendiaries such as the pocket time incendiary or white phosphorus grenade after the containers have been ruptured with explosives. Never use more than 1 pound of explosive on a drum--the explosion resulting from larger charges will cause a large part of the drum's contents to vaporize and flash-burn, thus leaving a small and perhaps insufficient amount to heat other drums to the bursting point. Also, large charges may tend to scatter the stack, thus making complete ignition more difficult.)

c. Other Products

If drum storage is known to contain heavier petroleum products, or if their contents are unknown, the saboteur should use small, long-burning incendiaries (PTI, sawdust, etc.) and small explosive charges. The charges should be placed as previously mentioned. The incendiaries should be placed in the flow path of released products (it may be necessary to dig a shallow ditch or ditches to guide the flow), but not close enough to the explosive charges to be affected by their blasts, since too much concussion may extinguish them. The incendiaries should ignite about a minute before the blast.

(Note: If the saboteur cannot obtain explosives the contents of a tank can be released through the water-draw-off valve at the bottom of the tank. The saboteur should either break the lock on the valve with a hammer or, using a sledge hammer, break the valve, which is made of cast iron, off the tank.)

2. Tank Storage

a. Fixed-Roof Tanks

The usual industrial storage tank is of the fixed-roof, cylindrical type, and because this type of tank may contain one

of a variety of products--e.g., solvents, gasoline, kerosene, fuel oil, etc.--the saboteur must prepare an incendiary parcel capable of igniting the most difficult of them (a heavy fuel oil), unless he definitely knows what the stored product is. Topped crude oil, kerosenes, fuel oils, and lubricating oils are extremely difficult to ignite by usual incendiary techniques. When large quantities of these products are released suddenly through holes blown in the tank with explosives, they must flow onto and over burning incendiaries of the conventional type before they can be brought to their flash points.

Most incendiaries are extinguished as soon as their oxygen supply is cut off. To prevent this from happening the saboteur may employ either of the following techniques:

(1) Gasoline and Breaching Charge

(a) A sealed rectangular can containing a minimum of 5 gallons of gasoline should be placed on the ground about 5 feet from the tank (see Fig. 154).

(b) A tightly sealed bottle containing a 1-pound diffuser igniter charge should be firmly fixed to the top of the can (see Fig. 154).

(c) A magnetic "doughnut" explosive charge or pole charge should be placed against the tank. The charge should be 1 foot above the level of the ground, to avoid any water the tank may contain.

(d) The tank-breaching charge should be primed to fire about one-half minute before the diffuser igniter. Each charge should have its own firing system. Upon detonation of the tank-breaching charge the tank's contents will gush out and cover the incendiary. Detonation of the diffuser igniter will scatter flaming gasoline over a wide area. The unburned gasoline, being lighter than fuel oil, etc., will tend to rise and burn at the surface. Since gasoline and fuel oil are both hydrocarbons, the gasoline will tend to dissolve into the heavier product, thereby lowering the latter's flash point and hastening widespread ignition.

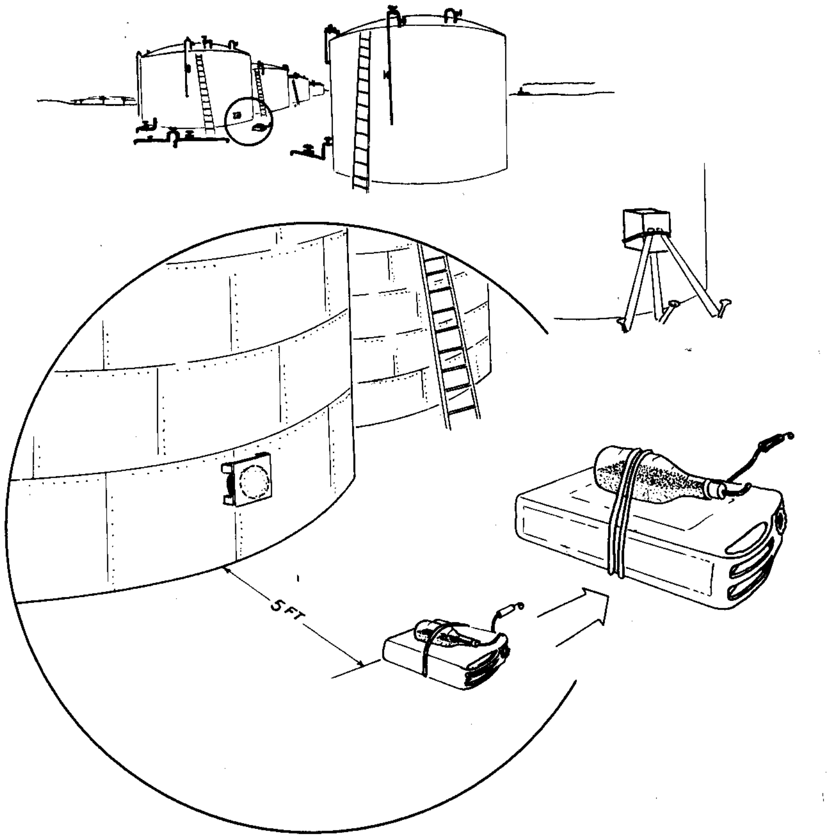


Figure 154

(2) Gasoline-Kerosene Mixture and Breaching Charge

(a) Two cork-stoppered quart bottles containing a 50-50 mixture of gasoline and kerosene should be fixed to an improvised float of cork, inner tube, etc. (see Fig. 155).

(b) An incendiary of the napalm or sawdust type should be fixed between the bottles, on top of cotton waste, rags, etc.

(c) The incendiary float should be placed far enough from the tank so as not to be affected by the blast.

(d) The tank-breaching charge should be placed about a foot above ground level.

(e) The tank-breaching charge should be primed to fire a minute before the incendiary charge. Each charge should have its own firing system. Upon detonation of the tank-breaching charge, the tank's contents will gush out and float the incendiary. Ignition of the napalm or sawdust mixture will cause vaporization of the gasoline-kerosene mixture until finally the cork stoppers will pop out of the bottles and pour their then flaming contents onto the surface of the heavier product.

b. Other Tanks

Floating-roof cylindrical, spherical, spheroidal, noded, and blimp tanks generally store products lighter than gasoline. For this reason the incendiary charge need not be as large as those recommended for heavier petroleum products. (Note: The saboteur should ascertain that target tanks contain enough product to warrant an attack. Many tanks are equipped with counterbalanced float indicators which measure the depth of product the tank contains. Empty tanks vibrate or "hum" for several seconds when struck a sharp blow.)

c. Other Considerations

The saboteur should take certain other precautions to assure a successful operation. These are:

(1) Destroy or damage nearby pumping machinery that is associated with the target tank(s).

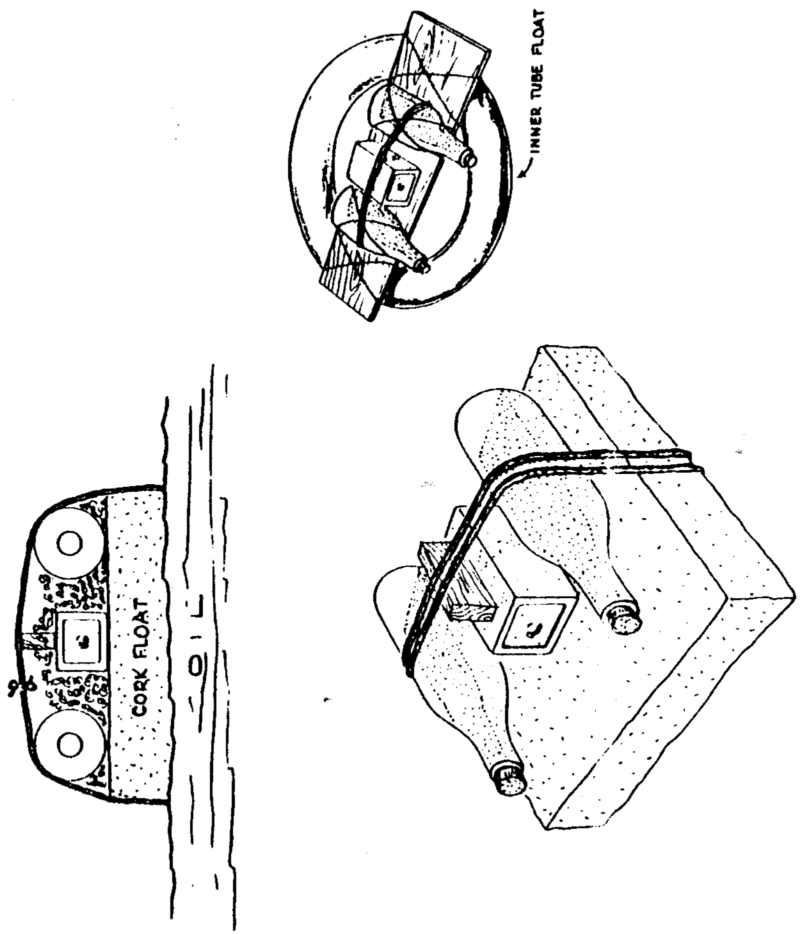


Figure 155

(2) Destroy or damage the tank's fire-fighting system (foam, steam pipes, etc.).

B. Outdoor Coal and Lignite Piles

Huge piles of coal or lignite are common around thermal power stations and large industrial plants. These generally are not worthwhile sabotage targets because: (1) they are difficult to ignite (due to moisture and problems of ventilation), (2) they do not burn rapidly, and (3) they are reasonably simple to extinguish or control. For harassment purposes, however, they may be attacked after prolonged dry spells when the wind condition is favorable (gusty, directional winds are preferred). The incendiary should be of the fusion agent or napalm type and should be of a size that will deliver persistent heat for the time necessary to ignite the target. Incendiaries should be placed on the windward side of dumps at the base of a pile of coal or lignite.

C. Baled Flammables

Rubber, raw cotton, rags, paper, etc. are baled for safety and handling purposes. While the substances themselves are highly flammable, their close confinement in bales makes it very difficult to ignite them, even with the fusion-agent incendiary. Bales are so resilient that any depression made in them by combustion is quickly sealed, thus eliminating the flow of that amount of oxygen necessary for rapid combustion. A bale once ignited tends to smolder and therefore can be removed to a safe area. The saboteur would do better to make the warehouse or storage facility which houses baled flammables his primary target. By breaking open one or more bales and using the contents for kindling, the storage facility itself might, in a short time, generate sufficient heat to ignite all of the other bales.

CHAPTER IV. HARMFUL ADDITIVES

SECTION 1. TYPES OF HARMFUL ADDITIVES

A. General

The use of harmful additives to accomplish sabotage is often depicted as the most formidable technique of the subtle saboteur. There are many limitations, however, on this means of sabotage. When one goes beyond the realm of the automobile gas tank, crank case, radiator, and battery, the use of additives becomes a highly technical subject and in many instances beyond the comprehension of the average saboteur. Unless a saboteur knows, or can be told, how much of a particular substance is required to cause the desired effect within a reasonable period of time, he ought not to use it unless his mission is general harassment. Even so, by so doing he may have signaled his presence to the enemy, since some of his additive may have been discovered in the course of routine quality-control procedures or even by accident.

B. Definition

Harmful additives, as described in this chapter, are substances which by their presence so change the properties of a material that they render it unfit for normal use, or which hasten the deterioration or breakdown of an article or machine. From a practical standpoint, an additive can only be considered as a sabotage weapon when a small quantity of it is capable of producing the desired deleterious effect within a reasonable period of time.

A substance may be referred to as a harmful additive only when it is thought of in connection with the damaging effect it is capable of producing on a material, process, or machine. In other words, sand is not a harmful additive until associated with such materials as lubricants or fuel in a machine. Because harmful additives must be associated with a target, they are classified according to the action they perform. Thus, there are corrosives, contaminants, abrasives, and miscellaneous impurities. Each of these categories is discussed in greater detail in later paragraphs of this Chapter.

C. Targets of Harmful Additives

The general targets of harmful additives are listed below:

1. Machinery (i.e., engines, motors, pumps, tools, etc.)

2. Fuels (i.e., gasoline, diesel oil)

3. Lubricants (i.e., oil, grease)

4. Electrical equipment (i.e., transformers, switches)

5. Materials in process (i.e., metals, chemicals)

6. Miscellaneous (i.e., textiles, food)

Since many targets may be attacked by a variety of additives, the saboteur should, whenever possible, consult with a technically competent person in order that the most suitable technique be employed. (The most suitable technique is not necessarily the most damaging, since in some cases extreme subtlety is necessary.)

D. Corrosives

Corrosives are chemical agents which destroy substances by chemical or electro-chemical reaction. Small quantities of such common chemicals as salt, hydrochloric acid, etc. may cause considerable damage by their quiet reaction, and without endangering the saboteur. On the other hand, certain reactions produce unusual heat and release fumes which would not escape detection. Also, several uncertainties exist in the use of corrosives, e.g., the time for complete failure of the target cannot be foretold accurately due to variables such as temperature, humidity, or the presence of lubricant and protective films on metal or other target surfaces that may tend to retard or prevent a chemical reaction.

1. Corrosion of Metals

The most common type of corrosion is that of rusting. Rusting is a general classification known as atmospheric corrosion, wherein the oxygen of the atmosphere reacts with the material in question. Most metals can be oxidized by atmospheric oxygen. Usually, water vapor must be present before any appreciable oxidation can take place. With iron, for example, 40-percent humidity is needed at ordinary temperatures before rusting will occur. The most common corrosives for metals are acids and bases dissolved in water.

2. Common Corrosives

a. Acids

(1) Sulfuric Acid (H_2SO_4)--Probably the most common of acids; is widely used in diluted form as an electrolyte for storage batteries. (Concentrated acid may be derived by boiling the battery solution until white fumes are given off. CAUTION: Hot sulfuric acid may spatter.)

(2) Hydrochloric Acid (HCL)

(3) Nitric Acid (HNO_3)

(4) Aqua Regia -- A mixture of one volume of concentrated nitric acid with three volumes of concentrated hyrochloric acid. The reaction of the two acids produces toxic gases.

(5) Hydrofluoric Acid (H_2F_2) -- Use of hydrofluoric acid is so hazardous that only experienced persons should handle it.

(6) Other Acids -- These include acetic acid, carbonic acid, chloric acid, oxalic acid, phosphoric acid, etc.

(Note: In diluting acids, pour the acid into the water. Never pour water into acid, since the reaction may be violent enough to cause the acid to fume and spatter excessively. Pour acid as you would beer -- tilt the water container and pour the acid against the side of the container.)

b. Bases (Alkalies)

(1) Sodium Hydroxide (NaOH) (Caustic soda and lye)

(2) Potassium Hydroxide (KOH)

(3) Calcium Hydroxide ($Ca(OH)_2$) (Slaked lime)

(4) Ammonium Hydroxide (NH_4OH)

c. Halogens (Salt Producers)

(1) Bromine (Br_2)

(2) Iodine (I)

d. Salts

(1) Chlorides

E. Contaminants

1. Types of Contaminants

a. Acidity Controlling Agents

These may be used to de-base chemical baths and thus alter the course of a chemical reaction. An example would be the addition of lye to an acid nitrating mixture.

b. Aging Agents

These may be used to hasten the deterioration of a final product. An example would be the addition of copper salts to rubber.

c. Gumming Agents

These may be used to promote the formation of gums in petroleum fuels and lubricants. An example would be the addition of paint drier to gasoline.

d. Metal De-basers

These may be used to alter the characteristics of metals. For that purpose they should be added to the target metal while it is being refined. An example would be the addition of phosphorous to molten iron.

e. Pro-Knocks

These may be used to change the octane rating of petroleum fuels. An example would be the addition of sulfuric acid to gasoline.

f. Solvents

These may be used to adulterate, dissolve, or expand materials. An example would be the pouring of gasoline on rubber.

g. Surface Active Agents

These may be used to cause water to foam or to form emulsions (liquid in liquid suspensions). An example would be the placing of soap in a steam boiler.

2. Use of Contaminants

Attempts to contaminate products being manufactured should, whenever possible, be made on the advice of a chemist or technician who is familiar with the process used in the manufacture of the particular target. This is necessary in order that the right amount and type of contaminant be selected, one that will not be detected by routine quality-control measures such as chemical analysis, spectroscopic tests, etc.

F. Abrasives

1. General

An abrasive is a substance that is used to wear or rub away, as by friction, another metal. Abrasives seemingly would have a maximum effect when used in lubrication systems where they come in close contact with metal surfaces which have a close tolerance or space between moving metal parts. In such a system, the maximum results are gained from an abrasive that is held in suspension in the lubricants.

2. Common Abrasives

a. 'Turtle Eggs' (Contaminant Abrasives) (Fig. 156)

"Turtle eggs" consist of ground cork, resins, carborundum, and metal alloys packaged in a latex rubber sack. Five sacks are packed per tin.

(1) Use:

The turtle egg was designed primarily for automobile-type engines -- one sack (1 ounce in weight) is recommended per each 5 quarts of lubricant. The sack may be dropped, as issued, into the oil intake pipe of a motor vehicle. When the oil reaches its normal running temperature, the latex rubber sack will dissolve and leave its contents to circulate with the lubricant.

When the oil intake pipe of a target vehicle is equipped with a baffle plate, it will be necessary to pour oil into the sack to form a slurry and then pour the slurry into the oil intake pipe.

If the oil intake pipe of a target vehicle is equipped with a screen, the screen should be removed before the egg is inserted.

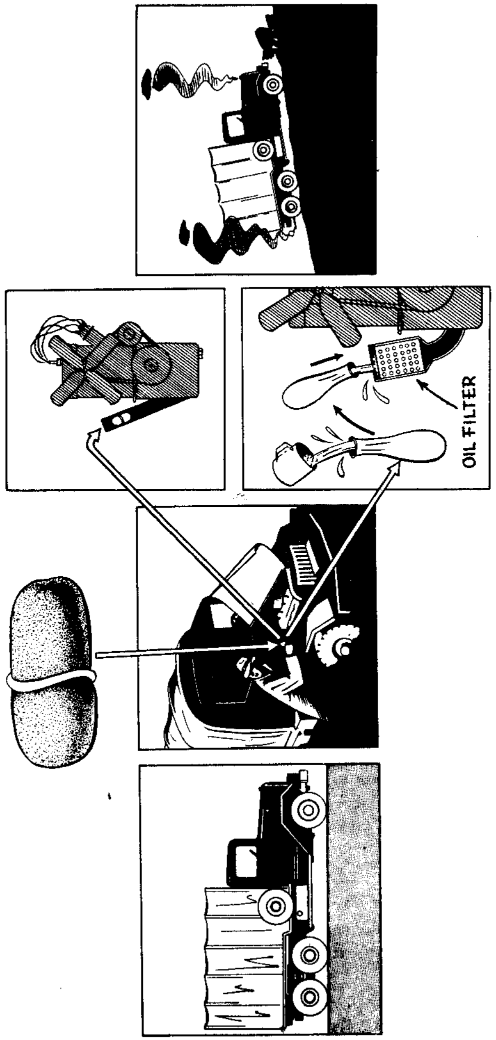


Fig. 156

(2) Action:

The resin causes particles of the abrasive to adhere to the cork particles, which are sufficiently buoyant to assure circulation to the bearing surfaces. In an engine not equipped with filters, stoppage results after from 5 to 45 minutes of operation, depending on the condition of the particular engine. The score marks produced by the abrasive are so minute that they may pass undetected or be attributed to normal wear. In vehicles equipped with oil filters the abrasive will be much less effective, since most of it is strained from the oil.

b. <u>Expedient Abrasives</u>

When turtle eggs are not available the saboteur may use one of the following substitutes, which are here arranged in the order of their effectiveness:

(1) Carborundum (silicon carbide, SiC)

(2) Emery particles

(3) Flare powder (magnesium and aluminum)

(4) Metal filings and powder

(5) Ground glass

(6) Sand

The disadvantage of expedient abrasives is their weight, i.e., they settle to the bottom of whatever container they may be placed in. Unless the lubricant or fuel is drawn off at the bottom of the container, little or none of the abrasive will be carried to the bearing surfaces.

G. Miscellaneous Impurities

1. <u>Definition</u>

Miscellaneous impurities include those additives which perform in a manner other than by corroding, contaminating, or abrading action.

2. Examples of the Use of Miscellaneous Impurities

a. Addition of Sugar to Gasoline

Sugar and gasoline will not mix to any great extent, but the gasoline will carry the granules of sugar to the combustion chamber of an engine, where the burning of the sugar produces sufficient carbon to stop the engine.

b. Addition of Grain to Gasoline

The grain, carried to the carburetor by the stream of gasoline, will expand and clog the small ports of the carburetor, thus causing the engine to stop.

c. Addition of an Incrusting Agent to Boiler Water

These cause deposits of scales on the internal surfaces of boiler tubes and associated equipment and thereby lower the efficiency of the unit.

SECTION 2. TARGET CHARTS

A. General

The following chart is arranged by target for the convenience of the user. It will be noted that the chart is incomplete as regards entries in the "Dosage" column; this is because chemists are not at present certain how much of some of the additives is needed to achieve the desired effect in sabotage work. Therefore, an additive for which no dosage is listed should not be used unless the saboteur has had ample opportunity to experiment with it and in that manner determine its efficiency for sabotage work.

Chart 13. Uses of Harmful Additives

TARGET	HARMFUL ADDITIVE	DOSAGE	EFFECT
I. GENERAL TARGETS			
Aluminum	Aqua regia		Causes rapid corrosion.
	Cupric chloride		"
	Ferric chloride		"
	Hydrochloric acid (50% concentration)		Reaction of acids produces toxic fumes.
	Potassium hydroxide	Slick or paste with water	Causes rapid corrosion.
	Sodium hydroxide	Slick or paste with water	"
	Sulfuric acid (25% concentration)		Causes slow corrosion.
Battery, Wet, Storage	Chloroplatinic acid	1 milliliter (ml.) per cell	Discharges cell in 2 hrs.
	Detergents	1 ml. per cell	Causes foaming and overflowing.
	Metal powders	1 oz. per cell	Short-circuits battery.
	Sodium hydroxide (NaOH)	1 tspn. per cell	Neutralizes acid.
Boiler Water	Aluminum sulfate	1 g. per 1,000 ml.	Forms scales.
	Calcium chloride	1 g. per 1,000 ml.	"
	Ferrous sulfate	1 g. per 1,000 ml.	"
	Magnesium chloride	1 g. per 1,000 ml.	"
	Sodium carbonate		Causes foaming (may result in water hammer).
	Sodium chloride	1 g. per 1,000 ml.	"
	Sodium phosphate		"
	Sodium silicate		"
Cable, Telephone (Copper)	Aqua regia		Causes rapid corrosion (reaction of acids produces toxic fumes).
	Hydrochloric acid (50% concentration)		Causes slow corrosion.

Cable, Telephone (Copper) (Continued)	Nitric acid (concentrated)		Causes moderate corrosion.
	Sulfuric acid (25% solution)		Causes slow corrosion.
Concrete	Hydrochloric acid (concentrated)		Causes slow disintegration.
	Hydrofluoric acid (handling is extremely hazardous)		Causes rapid disintegration.
Cooling System, Water	Ammonium chloride (NH_4Cl)		Causes slow corrosion.
	Calcium chloride ($CaCl_2.2H_2O$)		"
	Dry grains		Causes grain to expand and clog system.
	Hydrochloric acid (concentrated)		Causes slow corrosion.
	Sodium carbonate		Causes foaming.
	Sodium chloride (salt)	1 oz. per qt.	Causes slow corrosion.
	Sodium hydroxide		Causes corrosion.
	Sodium phosphate		Causes foaming.
	Sodium silicate		Causes foaming.
	Sulfuric acid (concentrated)		Causes slow corrosion.
Electric Motor and Generators	Abrasive on commutator (with transparent cement)		Causes arcing; scores surface.
	Abrasives in lubricant	(See Oil, Lubricating)	
Electric Transformer Oil (technique applicable to units down for maintenance)	Detergent and water (sodium carbonate, sodium phosphate, sodium silica)	1 ml. for 100 ml. of oil	Destroys insulating quality of oil.
Electronic Equipment (containing selenium rectifiers)	Mercury	Few drops	Mercury vapor induces rapid failure of equipment.
Fabrics	Acids		Causes fabric to disintegrate.
	Potassium hydroxide		Causes cotton to disintegrate, but not wool.
	Sodium hydroxide		"
Gasoline	Abrasives	1 lb. per automobile tank	Abrades and clogs.
	Bromine	15 cc. per 15 gal.	Has corrosive effect.
	Cashew nut shell oil (Prepare cashew nut shell oil by roasting the hulls in a pan until the oil runs out of them. Ten pounds of hulls will yield 2½ lbs. of oil. Handle with care; if oil is spilled on the skin a severe rash may result.)	1 oz. per 10 gal.	Causes gumming.

Gasoline (Continued)	Chlorinated hydantoins	1%	Causes gumming.
	Dry grain		Causes grain to expand.
	Linseed oil	1%	Causes gumming.
	Paint	1%	"
	Paint driers (naphthenates, etc.)	1%	"
	Phosphorus pentachloride (PCl_5)	1%	"
	Phosphorus oxychloride ($POCl_3$)	6 cc per qt. 1%	Causes corrosion. Causes gumming.
	Phosphorus trichloride (PCl_3)	1%	"
	Sugar, syrup, molasses	¼ lb. per 10 gals.	Clogs valves.
	Sulfuric acid	1 g. per liter	Causes knocks.
	Tertiary butyl thio nitrate	1 ml. per liter	"
Grain, Dry	Kerosene		Grain absorbs fumes.
	Odorants (Halogens, Hydrides)		Grain absorbs odors.
	Water		Causes grain to expand and perhaps to germinate.
Glass	Hydrofluoric acid (Handling is extremely hazardous)		Causes glass to disintegrate.
Hydraulic Machinery	(See Oil, Lubricating)		
Journal Boxes (Railroad equipment)	(See Oil, Lubricating)		
Machine tools	(See Oil, Lubricating and Oil, Cutting)		
Oil, Cutting	Acetyl chloride		Causes corrosion of machine and work.
	Aluminum sulfate	1 g. in 10 ml. water; add to 1 liter of cutting oil	Breaks down emulsion.
	Bromine		Causes corrosion of machine and work.
	Calcium chloride	1 g. in 10 ml. water; add to 1 liter of cutting oil	Breaks down emulsion.
	Hydrochloric Acid (concentrated)		Causes corrosion of machine and work.
	Iron sulfate	1 g. in 10 ml. water; add to 1 liter of cutting oil	"
	Manganese chloride	1 g. in 10 ml. water; add to 1 liter of cutting oil	Breaks down emulsion.
	Phosphorus oxychloride		Causes corrosion of machine and work.
	Phosphorus trichloride		"
	Sodium chloride	10 g. in 50 ml. water; add to 1 liter of oil	Breaks down emulsion.
	Sulfur chloride	10 g. in 50 ml. water; add to 1 liter of oil	"

Oil, Diesel	Cashew nut shell oil (See Gasoline)		Causes gumming.
	Chlorinated hydantoins	1%	Causes gumming up of injectors.
Oil, Lubricating, Vegetable	Sodium carbonate (washing soda) and water	1 g. to 10 ml. of water; add to 100 ml. of oil	Forms emulsions.
	Sodium hydroxide		Causes gumming.
Oil, Lubricating	Aluminum chloride ($ALCL_3$)		Causes gumming and corrosion.
	Ammonium hydroxide	2%	"
	Benzyl trimethyl	2%	"
	Bromine	2 cc. per qt.	Causes corrosion.
	Carborundum		Abrades.
	Cashew nut shell oil (see Gasoline)	2%	Causes gumming.
	Copper salts		Causes gumming and corrosion.
	Emery		Abrades.
	Flare powder (aluminum and magnesium)		"
	Ground glass		"
	Iodine	2 g. per qt.	Causes corrosion.
	Linseed oil	2%	Causes gumming.
	Naphthenic acid with an equal amount of sulfuric acid	10%	Causes corrosion and gumming.
	Paint driers (manganese naphthenate or iron naphthenate)	.02%	Causes gumming and corrosion.
	Phosphorus-oxychloride ($POcl_3$)	16 cc. per qt.	Causes corrosion.
	Phosphorus trichloride (Pcl_3)	16 cc. per qt.	"
	Sand		Abrades.
Rubber	Gasoline and other petroleum products		Spoils rubber.
	Nitric acid		Causes rubber to disintegrate slowly.
	Potassium hydroxide		Softens rubber.
	Sodium hydroxide		"
Rubber, Buna-S Synthetic	Nitric acid (HNO_3)	Conc. or dilute	Causes rubber to disintegrate.
	Sulfur chloride (S_2Cl_2)	Conc. or dilute	"
Rubber, Raw	Copper vulcanization accelerators	1 g. in 10 ml. of oil; inject into 10 lbs. of rubber with hypodermic needle	Causes rubber to disintegrate.
Steel and Iron	Aqua regia		Causes moderate corrosion.
	Chlorides: Ammonium, Aluminum, Copper, Magnesium, Zinc		Causes slow corrosion.
	Ferric chloride		"
Steel and Iron (Continued)	Hydrochloric acid (concentrated)		Causes slow corrosion.
	Nitric acid (40% solution)		"
	Sulfuric acid (25% concentration)		"
Steel, Stainless	Cupric chloride and ferric chloride		Causes slow corrosion.
	Ferric chloride		"
	Hydrochloric acid		"
	Mercuric chloride		"
Wood	Hydrochloric acid (50% concentration)		Causes slow corrosion.
	Sulfuric acid (50% concentration)		"
II. METALS BEING PROCESSED			
Aluminum	Copper	.05%	Renders more susceptible to corrosion.
	Iron	2 oz. per 100 lbs.	Makes brittle.
	Potassium	1%	Renders more susceptible to corrosion.
	Sodium	1%	"
	Zinc	1%	"
Copper	Antimony	1%	Makes brittle (subject to spectroscope discovery).
	Arsenic	1%	"
	Bismuth	.005%	"
	Phosphorus	1%	"
Cryolite (for aluminum)	Calcium phosphate	1 g. per 20 kg.	Makes brittle.
	Di-sodium phosphate	1 g. per 20 kg.	"
Lead	Bismuth		Renders more susceptible to corrosion.
	Potassium	0.1%	"
	Sodium		"
	Zinc	0.1%	Impairs castability.
Lead for Storage Battery Plates	Calcium	1%	Shortens life of battery.
Magnesium	Copper	1%	Makes brittle.
	Iron	1%	"
	Nickel	1%	"
	Potassium	1%	Renders more susceptible to corrosion.
	Sodium	1%	"
Tin Plating	Oil or grease		Causes tin to adhere poorly and thus renders plating more susceptible to corrosion.
Tin (for solder and bearings)	Potassium		
	Sulfur		

Tungsten	Arsenic		Impairs strength and conductivity.
	Potassium	1%	Renders more susceptible to corrosion.
	Sodium		"
Zinc (for die castings)	Lead	.005%	Renders more susceptible to corrosion.
	Potassium	1%	"
	Sodium	1%	"
	Tin	.002%	"
Zinc Plating Bath	Germanium	.00001%	Causes plating to be inferior.

CHAPTER V. SABOTAGE BY PHYSICAL ACTS

SECTION 1. INTRODUCTION

A. General

Sabotage by physical act consists of those acts of commission or omission by which targets are either destroyed or damaged by tampering or misuse or are allowed to deteriorate as a result of poor or insufficient maintenance.

Ordinarily, sabotage by physical act should be used as a subtle tool and must be widely employed if any worthwhile effect is to be derived. Also, any program of such sabotage within an industrial target area ought to be directed and closely coordinated in order that a variety of troubles develop, instead of a repetition of only one or two distinctive faults that would soon be recognized as sabotage.

B. Advising the Saboteur

A saboteur in this field will have to reverse his thinking in order to become effective, and he should be told this in so many words. Where he formerly thought of keeping his tools sharp, he now should let them grow dull; where in the past he normally has been diligent, he should now become indolent and careless. He should fully exploit "thoughtlessness"--for instance, an object may be misplaced or improperly substituted for a second article, etc. This type of activity, sometimes referred to as the human element, is frequently responsible for costly accidents and delays. These are a few of the many examples that might be used to orient those individuals who are willing to take an active part in sabotage but require encouragement and suggestions as to how they may proceed. Once a saboteur has adapted himself to this "reverse" philosophy he will perceive innumerable ways of disrupting production which is of benefit to the enemy.

C. Techniques of Sabotage by Physical Act

It is impossible to set down in writing all of the various ways that an individual might disrupt, damage, or destroy the great variety of sabotage targets. Therefore, the following pages, which are devoted to examples of various techniques as applied to some targets, are presented to afford the reader an idea of the scope of the subject and to stimulate thought on his part along similar lines:

1. All friction surfaces of machinery require lubricants to reduce friction, heating, and erosion. Neglecting to lubricate machinery

or substituting an oil of improper viscosity may cause inefficient operation, which may reduce the life of the machine substantially. An ideal situation would be one in which an improper oil was used for a whole series of machines.

2. Wear on any machine can be hastened by uncovering a filter and poking a pencil or other sharp instrument through the mesh. This will permit the normal cuttings and sludge to circulate throughout the system.

3. Certain types of cutting or drilling machines require oil to lubricate and cool the tool and the work. If insufficient oil or oil of the wrong type were furnished to the machine, heating might take place and possibly result in scored or broken tools and/or work.

4. A machine tool operator can let cutting tools grow dull. Such tools will then be inefficient and may damage materials on which they are used.

5. Various types of electrical relays and contacts may be altered or reversed to perform unsatisfactorily. For example, the spark gap, or airspace, between the contacts of a sparkplug is set at a certain distance with a metal gauge to assure a spark of a certain length, heat, etc. If this gap is opened or closed a fraction of an inch, the engine will function improperly or it may not function at all.

6. Rubber and composition washers may be substituted for metal washers to allow stress or materials flowing around them to cause rapid deterioration. For example, rubber washers or gaskets would not last long if used where gasoline came in contact with them.

7. One may imagine what would happen if a sign reading "Gross Load 15 Tons" were substituted for one on a particular bridge reading "Gross Load 5 Tons." Such an act might result in the loss of a vehicle and a bridge.

8. Alterations, errors, etc., committed in paper-planning stages might offer the saboteur unusual opportunities. For example, an engineer computing stresses and strains on structural members, machinery parts, etc. might knowingly neglect to allow a sufficient safety-factor margin and as a result the items produced would operate under an extreme stress or strain and thus rapidly deteriorate.

9. A workman who does not report a faulty piece of equipment or take action to have it repaired or replaced will increase the

damage. For example, the railroad man who discovers a journal box without lubricant or a cracked wheel, etc. and who fails to make remedial action is endangering the whole train of which the defective car or coach is a part.

10. Machinery requiring various types of fasteners such as nuts, bolts, screws, cotter pins, etc. may be damaged or at least be subject to damage if these fasteners are not properly secured. Nuts, bolts, and machine screws that are either overtightened or undertightened may shear off under pressure or allow damaging vibration. Cotter pin legs that are not spread properly may allow the pin to slide out. All such actions permit slippage, vibration, excessive stress, etc. which after a time may result in serious damage.

11. A machinist or maintenance man might "accidentally" slip so that a sharp tool in his hand might gouge or notch a revolving shaft. A notch or discontinuity on the surface of an object concentrates stresses at the notch's apex. As notched surfaces rotate, "fatigue" is set up in the metal and eventually a breakdown occurs.

12. Drainage systems may sometimes be blocked with rags and various other types of debris. Another technique involves the use of a large sponge. The size of the sponge must be reduced if it is to be introduced through normal drains. This is accomplished by saturating a dry sponge in a thick starch or sugar solution, squeezing it tightly into a ball by wrapping it with string, and then allowing it to dry. When the string is removed the sponge will remain compressed and can then be easily flushed into the drainage system. When the sponge becomes wet again it will expand and will probably jam in a pipe elbow, thus blocking the drain.

13. Electric fuses can be rendered ineffective by placing a coin behind the "screw-in" type fuse or by bridging the air gap between the cylindrical or bar-type fuse holders with a piece of heavy wire. An overloaded circuit may start a fire or blow out a central office fuse, which might in turn interrupt power distribution to a large area.

14. Railroad workers may frequently have an opportunity to switch shipping labels or other instructions on freight cars, or to alter certain destination markings on rolling stock. Misrouting and mislabeling causes confusion and loss of time.

SECTION 2. TARGET CHARTS

A. General

The comparatively few techniques listed in this chart obviously do not cover all cases in which sabotage by physical act may be carried out; it is the purpose of the chart to stimulate thought along similar lines in the saboteur, who is on the ground and is thoroughly familiar with target equipment in his area.

Chart 14. Sabotage by Physical Acts

TARGET	PHYSICAL ACT	EFFECT
1. Acetylene Welding Equipment	a. Punch a hole in the acetylene line. b. Seal orifice by hammering torch on a solid object. c. Damage oxygen acetylene storage tank manifold.	a. Gas lead may cause accidental fire. b. Harassment. c. Harassment.
2. Air Brake Systems	a. Stuff rags, gasoline, sand, etc. into hoses. b. Cut hoses with heavy knife, saw or axe. Turn stopcocks to "Off" position after vehicle has started moving.	a. Jamming and premature wear. b. Leaves vehicle without brakes.
3. Air Compressors	a. Close valve between compressor and storage tank. b. Remove air strainer or filter from air intake. c. Smash small cast-iron heads with maul. d. Slash belts, jam driving chains. e. Fail to drain water from pressure tank.	a. May burst compressor or pipe if there is no pop-off valve. b. Dust erodes pistons and valves. (Dust and heated air may form an explosive mixture.) c. Harassment. d. Harassment. e. Harassment.
4. Aircraft	a. Put rags in oil tanks. b. Notch control cables at generally inaccessible points. c. Pinch hydraulic, oil, fuel, etc. lines.	a. Jams feed lines. b. Weakens cables to point where stresses may break them. c. Harassment.
5. Arc Welding Equipment	a. Cut ground wire; splice insulation only. b. Change heat tap.	a. Will electrocute welder if he touches work. b. Burns through work.
6. Automobiles	a. Strip threads of hydraulic brake wheel cylinders. b. Notch drive shaft. c. Overtighten wheel bearings.	a. Fluid will leak out at later date, causing brake failure. b. Increases stress fatigue; this causes premature breakdown. c. Increases friction, and may cause premature breakdown.

6. Automobiles (Continued)	d. Loosen wheel lug bolts. e. Loosen steering box bolts.	d. Vibration may loosen these sufficiently to cause loss of the wheel. e. Box will drop off after some operation, leaving vehicle without steering.
7. Batteries, Storage	a. Crack cases with hammer. b. Break posts loose with hammer. c. Drive a screwdriver slantwise and downward through the cell opening. d. Drain electrolyte and replace with water.	a. Electrolyte drains; causes failure. b. Vibration will ultimately break posts off. c. Will pierce battery plates and cause short circuits. d. Premature failure.
8. Bearings	a. Score journal bearings longitudinally. b. Overtighten roller and ball-type bearing. c. Overload.	a. Oil will remain in score mark, permitting excess friction. b. Premature breakdown. c. Premature failure.
9. Blowers	a. Tie down or render inoperable the governor or overspeed trip. b. Loosen Allen screws or collars on impeller of small blowers. c. Insert nuts, bolts, rags into intake. d. Insert dirt, etc. in engine forced feed draft (necessary to lift filter first).	a. Stresses of overspeed will generally weaken unit and hasten breakdown. b. Vibration will permit impeller to hit housing. c. Destroys or damages impeller. d. Will score bearing surfaces.
10. Cables	a. Use undersize pulleys or sheaves. b. Cause cable to pinch on drum. c. Reverse lay of cable on drum. d. Offset sheave alignment. e. Twist cable before weight is lifted.	a. Premature wear. b. Premature wear. c. Cable will kink and pinch. d. Premature wear. e. Cable has tendency to kink.
11. Conveyors (Belt, Chain, etc.)	a. Cut "V" belts or driving belts. b. Insert metal objects in driving chain links. c. Overtighten belts on one side.	a. Harassment. b. Temporary interruption when these pass into sprockets. c. Premature breakdown.
12. Cranes	a. Electric cranes: open rheostat wide to start. b. Remove wedges from jib support cables. c. Remove cotter pins from topping lift shaft located at the top of A-frame. d. Insert bolt, etc. between teeth of cast iron sluing gear. e. Remove pins from sluing or traversing rollers. (See Cables)	a. Harassment; blows fuses. b. Jib will drop when heavy weight is hoisted. c. After some operation A-frame shaft will pull loose and drop jib with heavy cargo. d. When pinion gear meshes with sluing gear, teeth will break off of pinion or sluing gear. e. Crane may tip.
13. Drawing and Blueprints	a. Change specifications, etc. b. Obliterate figures, terms.	a. Harassment. b. Harassment.

14. Electric Motors and Generators	a. Short-circuit the field with jumper wire. b. Jam carbon brushes hard against commutator. c. Overlubricate small units. d. Clog oil holes with dirt, etc.	a. Immediate breakdown. b. Excessive brush and commutator wear. c. Lubricant coats armature and field winding insulation and causes more rapid deterioration and short circuits. d. Slow deterioration due to insufficient lubricant.
15. Electric Transformers	a. Drain coolant from valve at base of tank (special wrench may be necessary). b. Throw "bolas" type of cable so as to bridge space between conductors or between conductors and transformer tank. c. Shoot with rifle into small transformer tanks. d. Shoot bushings (insulators). e. Bridge conducting wires with rope lengths. Better still, bridge conducting wires with a heavy wire.	a. Unit will shut off when high temperature is reached. b. Short-circuits or grounds circuit (may seriously damage unit). c. Will drain coolant and may short-circuit coils. d. May shatter or be weakened sufficiently to cause breakdown. This might cause a short circuit or a ground. e. When rope becomes wet it will act as a conductor and cause a short circuit.
16. Electric Transmission Lines	a. Loosen turnbuckles on stress pylons, towers, etc. b. Throw "bolas" type of conductor so as to bridge gap between adjacent wires.	a. Wind, sleet stresses may be sufficient to topple. b. Short circuit (power interruption).
17. Electrical Systems	a. Replace fuses with copper wire, etc.; then overload circuits. b. Bare wires where they are likely to touch.	a. Resulting short circuit is liable to result in fire. b. Resulting short circuit is liable to result in fire.
18. Engines, Diesel	a. Bend fuel lines and injectors with hammer. b. Smash small cast-iron flywheels with maul. c. Damage starter mechanism (electric motors, gasoline engines, etc.).	a. Temporary interruption. b. Temporary interruption. c. Unit temporarily inoperable.
19. Engines, Otto Cycle, Gasoline	a. Loosen head bolt nuts along one side of engine. b. Overtighten connecting rods, valve tappets, etc. c. Draw pencil line from top to base of spark plugs. d. Stopper tail pipe with rag, potato, etc. e. Punch pinhole in fuel line and cover with soap. f. Remove lock washers from carburator, fuel pump, etc.	a. Blows gasket. b. Excessive friction, premature wear. c. Short-circuits plugs. d. Prevents operation. e. Soap dissolves or falls off; fuel leaks, may cause vapor lock. f. Vibration will loosen parts.

20. Furnaces (Boilers)	a. Run oil into idle burners.	a. "Blow back" will result when fire is lit.
21. Gauges (Thermometers Pressure, etc.)	a. Sharp blow with hand tool.	a. Harassment.
22. Gears	a. Alter mesh setting. b. Insert bolts or metal objects between gear teeth.	a. Causes premature wear. b. May bend gear out of alignment or break off teeth.
23. Hand Tools	a. Hide or misplace. b. Misuse. c. Harden improperly.	a. Harassment. b. Harassment. c. Premature wear (reheating embrittles).
24. Hydraulic Press	a. Weaken table support pins.	a. Work will fall.
25. Hydraulic Systems	a. Punch pinhole in hydraulic line at out-of-the-way location.	a. Harassment; may cause serious failure at later date.
26. Locomotives, Steam	a. Drop bolts, stones, etc. into smokestacks not equipped with spark arresters. b. Pinch copper lubrication tubing. c. Sharp blow on cast-iron heads of air compressors with maul. d. Strike a sharp blow on gauges in locomotive cab. (See Steam Engines)	a. Bolts, etc. may jam cylinder valve and break same. b. Cuts lubricant supply to various bearings. Hastens breakdown. c. Harassment; delay. d. Harassment; delay.
27. Machine Tools	a. Disturb level of machine. b. Disturb calibration of measuring instruments. c. Change RPM of source of power. d. Dull saws, shapers, planers, drills, etc. e. Loosen spindle nut on saws, grinders, etc. f. Run machine at high speed under heavy load. g. Use wrong wheel on a grinding machine. h. Put excessive wheel dressing on grinding machines. i. Break carbide guide blades on centerless machines j. Put oil or grease on V-belt. (See Hand Tools)	a. Very slow deterioration. b. May result in production of inferior work. c. Premature wear. d. Results in inferior work. e. Wheel, saw, etc. may fly off during operation. f. Excessive wear on machine. g. Excessive wear on wheel and poor surface finish on product. h. Increases wheel wear. i. Blades, which are difficult to obtain, break easily. j. Causes slippage. Belt must be removed and cleaned or thrown away.
28. Pallets	a. Weaken center of those pallets which support weights during crane lifts.	a. May cause cargo to fall.
29. Precision Instruments	a. Bend calipers, micrometers, etc. (See Machine Tools)	a. May result in the production of inferior parts.
30. Pumps	a. Tie down or render inoperable the pendulum, governor, or overspeed trip.	a. Stresses of overspeed will generally weaken unit and hasten breakdown.

30. Pumps (Continued)	b. Place rags, etc. in suction side. c. Puncture intake hose or pipe. d. Close valve on discharge side of motor-driven positive displacement pumps (technique not applicable to pumps equipped with relief valve). e. Overtighten one side of packing gland. f. Handle micrometer roughly. g. Overtighten jaws of micrometer. h. Fail to clean gauge-testing equipment.	b. Will clog impeller valves, etc. c. Pump will lose prime. d. Instantaneous effect; pump or pipe may burst. e. Excessive wear; premature breakdown. f. Causes an incorrect reading of one or two thousandths of an inch. g. Causes an incorrect reading of one or two thousandths of an inch. h. Gauges will be off and all work checked with gauges will be off size.
31. Radiators, Engine	a. Pour cold water in overheated radiators. b. Insert rags, grass, etc.	a. Rapid cooling may crack engine block. b. Clogs system.
32. Railroad Cars	a. Set manual brakes. b. Remove cotter pins, shackle bolts, etc. from braking linkage, wheel suspensions, etc. c. Remove lubricant from journal boxes. (See Air Brakes)	a. Harassment. b. Causes hotbox, might cause partial derailment. c. Causes hotbox.
33. Railroad Rails	a. Loosen rail bonds. b. Remove tie spikes or screws from outside rail on curves (heavy tools required). c. Jam switches and guard rails with fishplates, tieplates, chairs, etc. d. Pour water on switch points during freezing weather. e. Disconnect fishplates; pull enough spikes to bend one rail inward. (See Air Brakes)	a. Harassment. Block signals will not function. b. Momentum may tip the track and cause derailment. c. May cause partial derailment. d. Switches made inoperable. e. Derailment.
34. Recording Gauges (Pressure, temperature PH, salinity, etc.)	a. Bend needle or stylus point out of alignment. b. Squeeze copper tubing associated with unit.	a. Accidental explosions or other considerable damage may occur. b. Gauge will cease to function.
35. Refrigerating Units	a. When unit is not operating, turn the valve between the compressor and the condenser to the "Off" position. b. Set thermostats to highest or lowest position. c. Puncture brine lines at points where corrosive brine will do the most damage. (See Air Compressors)	a. If unit is started with valve closed, the compressor may burst. b. May freeze products or allow them to spoil. c. Harassment.

36. Roads	a. Substitute road signs. b. Erect false barricades. c. Scatter road nails. d. Stretch steel cables across high-speed roads and anchor to heavy trees during hours of darkness.	a. Harassment. b. Harassment. c. Harassment. d. Harassment.
37. Rock Crushers	a. Drop metal tools into the material being fed to crusher (not recommended for systems equipped with magnets).	a. Will jam or break the crusher.
38. Rubber Tires	a. Slash. b. Overinflate or underinflate. c. Insert stones, etc. in casing while tires are off rims. d. Put kerosene or gasoline in tubes while they are being patched. e. Misalign front wheels of cars or trucks.	a. Harassment. b. Premature wear. c. Premature wear. d. Premature wear. e. Premature wear.
39. Safety Valves (Boilers, Tanks, etc.)	a. Misalign with hammer. b. Daub paint or tar on operating mechanism.	a. Will malfunction. b. Will malfunction.
40. Screw and Bolt Threads	a. Mutilate those over 2" in diameter.	a. Harassment (dies of this size are difficult to obtain).
41. Spot Welding Equipment	a. Shut off cooling water valve.	a. Steam pressure may be sufficient to cause explosion.
42. Steam Engine (Reciprocating)	a. Fail to open cylinder drains when engine stops (this permits steam to condense). b. Fail to allow sufficient warm-up time; open the throttle completely. c. Place metal object on crosshead guide. (Object should be shorter than length of stroke. Placement to take place while unit is idle.)	a. Water hammer (unless cylinders are "blown" before operation). b. Excessive friction and stress will cause premature breakdown. c. May crack cylinder or crosshead guide when unit is started.
43. Steam Turbine	a. Fail to allow sufficient warmup time; open throttle valve fully to start. b. Fail to drain turbine casing before starting. c. During turbine operation, shut off supply of cooling water to oil cooler.	a. Expansion factors caused by sudden change of cold to hot temperature may warp blading. b. Creates excessive vibration which will damage unit seriously after a few minutes of operation. c. Heat will break down the oil. Unit will overheat.
44. Tank Cars (Rail and Trunk)	a. Overfill or underfill. b. Tamper with heating elements on units carrying heated products during cold weather. (See Valves and Safety Valves.)	a. Permits excessive pressure build-up or allows sloshing on grades. b. Permits freezing.

45. Valves (Liquid and Gas-Closed systems)	a. Reverse setting.	a. Causes loss of product or allows excessive pressure to build up.
46. Water Towers, Stand-Pipes, Hydrants, etc.	a. Break off handwheel, lever, etc. b. Quench fires in braziers. c. Strip threads.	a. Harassment; causes delay until repairs are made. b. Will cause freezing of water and consequent delay. c. Harassment.

APPENDIX A: COMMON SOURCES OF CHEMICALS

It is important for the operator to know where the chemicals mentioned in this Handbook may be obtained; the chart below lists industries or occupations in which a particular chemical is used and which therefore form a relatively stable source of supply for the operator.

INDUSTRIAL OR OCCUPATIONAL SOURCE / CHEMICAL	Agriculture	Auto-Aircraft	Building Materials	Cellulose	Ceramics	Chemical Processes	Drugs	Electrical Supplies	Explosives	Fats	Foods	Fuels	Hospitals	Laundries	Leather	Metals	Organic Syntheses	Paints	Pesticides	Petroleum	Physicians	Plastics	Preservatives	Printing	Rubber	Sanitation	Schools	Solvents	Sugar	Textile
Acetic Acid				✓		✓	✓				✓		✓	✓	✓		✓	✓	✓		✓	✓			✓		✓	✓		✓
Acetone		✓		✓			✓		✓	✓			✓		✓		✓	✓		✓	✓	✓		✓	✓		✓	✓		✓
Aluminum	✓	✓	✓				✓	✓			✓		✓			✓	✓	✓									✓			
Aluminum Dust									✓							✓		✓						✓			✓			
Alundum					✓			✓																						
Amines						✓							✓		✓		✓		✓						✓					
Amyl Mercaptan																	✓													✓
Aniline							✓										✓					✓			✓		✓	✓		✓
Aqua-Dag					✓															✓										
Aqua Regia													✓								✓						✓			
Arsenic					✓		✓						✓			✓											✓	✓		
Barium Nitrate						✓	✓		✓								✓										✓			
Benzene		✓				✓	✓		✓			✓	✓		✓		✓	✓		✓	✓	✓					✓	✓		
Bismuth					✓											✓					✓			✓			✓			
Bleaching Powder	✓						✓							✓			✓		✓							✓	✓			✓
Carbon Tetrachloride						✓	✓	✓					✓	✓		✓	✓	✓	✓						✓		✓	✓		✓
Cashew Nut Shell Oil																		✓	✓			✓	✓	✓	✓					
Castor Oil		✓					✓	✓		✓			✓		✓						✓	✓			✓					✓
Chlorinated Hydantoins							✓															✓								
Chloropicrin											✓						✓		✓											✓
Collodion							✓						✓		✓			✓			✓			✓			✓	✓		
Fuming Nitric Acid							✓		✓				✓			✓	✓				✓	✓		✓			✓			✓
Graphite							✓	✓								✓		✓						✓			✓			
Hammer Scale																✓														
Hydrochloric Acid		✓		✓	✓	✓	✓	✓					✓		✓	✓	✓	✓		✓	✓			✓	✓		✓		✓	✓
Hydrofluoric Acid			✓	✓	✓	✓					✓			✓		✓				✓							✓			✓
Hydrogen Peroxide							✓		✓		✓	✓	✓		✓					✓	✓	✓		✓	✓	✓	✓		✓	✓
Iron Oxide					✓	✓	✓				✓					✓		✓									✓			✓
Japan Drier																		✓												
Kerosene	✓											✓															✓			
Lead	✓		✓			✓		✓	✓							✓		✓								✓	✓			
Lead Azide									✓																					
Linseed Oil	✓			✓			✓								✓			✓				✓		✓			✓	✓		✓
Magnesium		✓	✓			✓		✓	✓							✓	✓										✓			
Magnesium Dust						✓			✓															✓			✓			
Mercaptans				✓									✓								✓						✓			
Mercury		✓					✓	✓	✓				✓							✓	✓						✓			
Mill Scale		✓														✓														
Naphtha		✓										✓	✓	✓				✓	✓			✓		✓	✓		✓	✓		
Nitric Acid				✓		✓	✓		✓				✓			✓	✓				✓						✓			✓
Nitrobenzene			✓	✓													✓			✓		✓				✓		✓		
Phosphorus	✓								✓										✓								✓			
Phosphorus Oxychloride																	✓											✓		
Phosphorus Pentachloride																	✓					✓					✓			
Phosphorus Trichloride											✓					✓											✓	✓		
Potassium						✓											✓										✓			
Potassium Chlorate				✓			✓		✓				✓				✓		✓		✓						✓			✓
Potassium Dichromate				✓	✓	✓	✓		✓				✓		✓	✓		✓			✓			✓			✓			✓
Potassium Hydroxide				✓			✓						✓			✓	✓	✓			✓			✓			✓			✓
Potassium Nitrate	✓								✓		✓					✓											✓			
Potassium Perchlorate							✓		✓				✓				✓							✓			✓			
Potassium Permanganate				✓			✓						✓		✓		✓		✓		✓			✓		✓	✓			✓
Sodium Chlorate						✓	✓		✓				✓		✓		✓		✓								✓			✓
Sodium Chloride	✓		✓		✓	✓	✓			✓	✓		✓				✓				✓						✓			
Sulfur					✓	✓	✓		✓		✓		✓						✓		✓	✓			✓					✓
Sulfuric Acid	✓	✓		✓		✓	✓		✓	✓			✓		✓	✓	✓	✓		✓	✓	✓					✓			
Sulfur Chloride				✓	✓	✓	✓									✓		✓	✓					✓	✓		✓		✓	✓